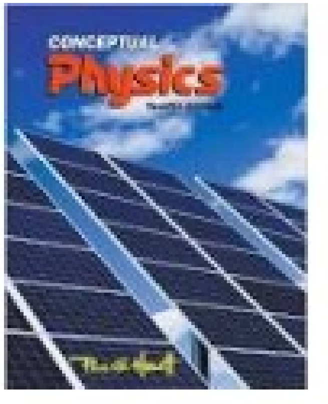
Newton’s laws – slide 1
impulse-momentum theorem – slide 26
Newton’s second law in 2D – slide 55
gravitational law – slide 71
weightlessness

References:

Conceptual Physics by Paul G. Hewitt



Physics / Edition 8
by John D. Cutnell, Kenneth W. Johnson, Cutnell

Inquiry into Physics
Vern J. Ostdiek, Donald J. Born

Newton's first law :law of inertia

- **Newton's First Law of Motion** states: An object will remain at rest or in motion with constant velocity unless acted on by a net external force.
- An **external force** is a force applied to the object from some other object.
  - force from an impact, gravity, air resistance, etc
  - Net force = 0 means acceleration = 0

    Velocity = constant

    same magnitude and same direction

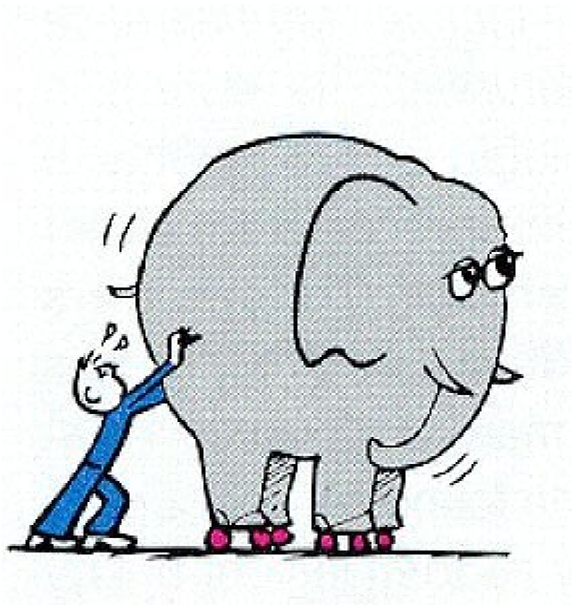
Inertia is the natural tendency of an object to remain at rest in motion at a constant speed along a straight line.

The *mass* of an object is a quantitative measure of inertia.

SI Unit of Mass: kilogram (kg)

misconception: " Motion requires force " WRONG.
A puck initially hit will keep moving on the ice until it is stopped by a wall or by a player.
Motion does not require force.

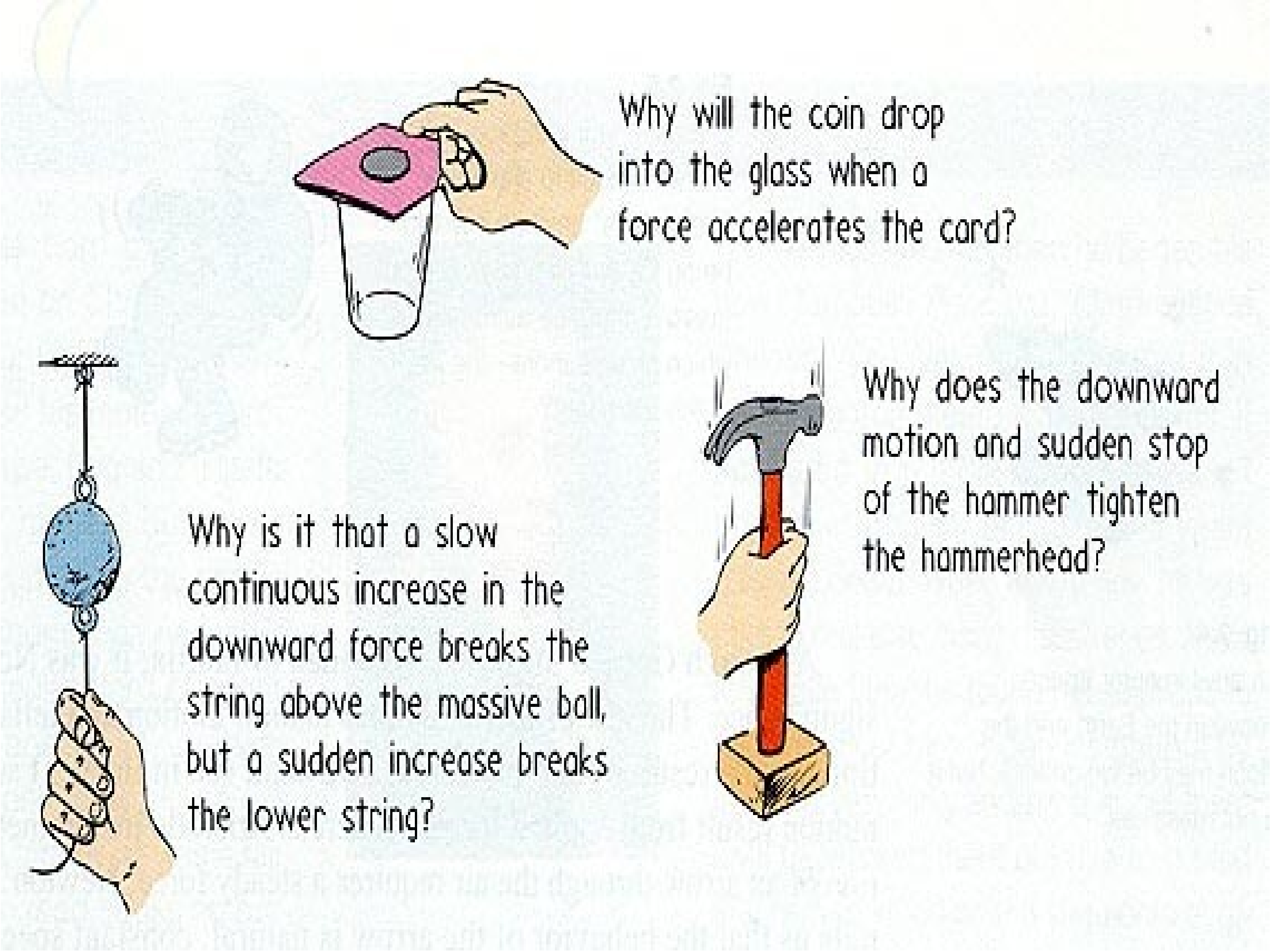
A net Force is only required to change the motion.
to speed up an object, to slow it down, to stop it , to get it to move or to change its direction,



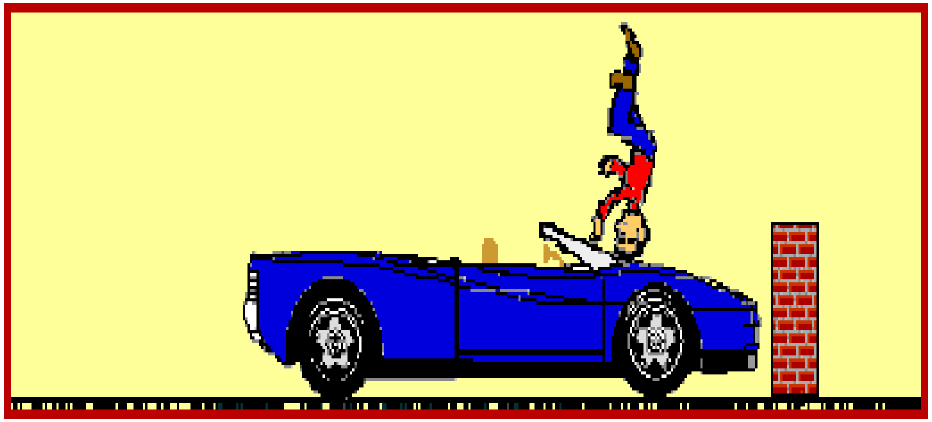
Mass is amount of “ stuff” or matter in an object.
Mass is a measure of inertia. How much an object resists a change in motion. Its laziness to change Its direction or speed.

Source: Conceptual Physics, Paul Hewitt

Demo : inertia
Videos:crash test / inertia loop /inertia string / table cloth 1 & 2 /

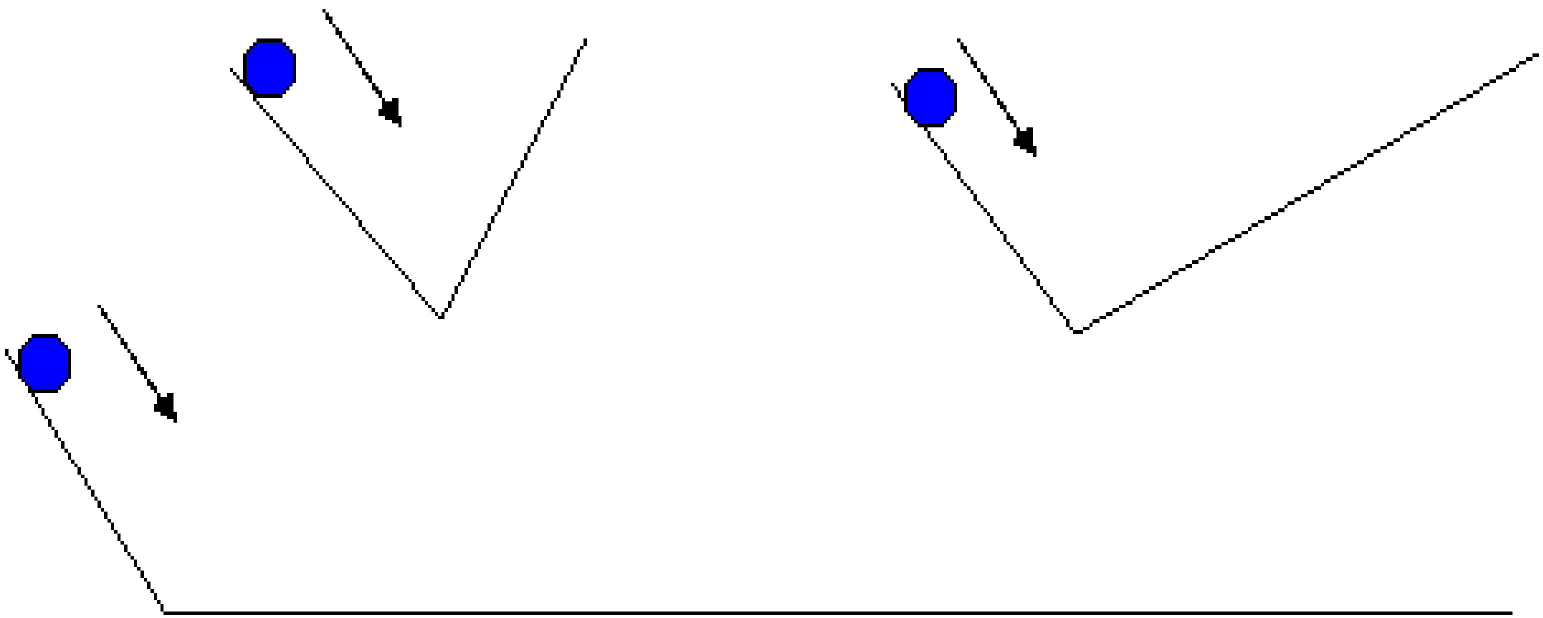


WHAT HAPPEN TO THE PASSENGERS
OF A CAR WHEN IT ABRUPTLY BREAKS ?
OR SPEED UP ?
WHY DO YOU NEED TO WEAR A SEAT BELT ?



HOW CAN YOU EXPLAIN THE TABLE TRICK
USING INERTIA PRINCIPLE ?

USING A THOUGHT EXPERIMENT, GALILEO REASONED THAT ARISTOTLE WAS WRONG.
IF THERE IS NO NET FORCE, AN OBJECT IN MOTION STAYS IN MOTION, AT THE SAME SPEED AND THE SAME DIRECTION. Describe this experiment:



An elephant has a large inertia and can run very fast. What could you do to escape a charging elephant ? (using Newton;'s 1st law)

stinger missiles are heat seeking missiles. They detect infra red and can hit planes. They reach them because the " feel " the heat. If you are an experienced pilot, how can you avoid the stingers ?

Let s say you try to push a large mass like an Anvil.
Is it harder to push it on Earth or in space, out of gravity reach ? (tricky)

A pipe is bent into the shape shown and oriented so that it is sitting horizontally on a table top. You are looking at the pipe from above. The interior of the pipe is smooth. A marble is shot into one end and exits the other end. Which one of the paths shown in the drawing will the marble follow when it leaves the pipe?

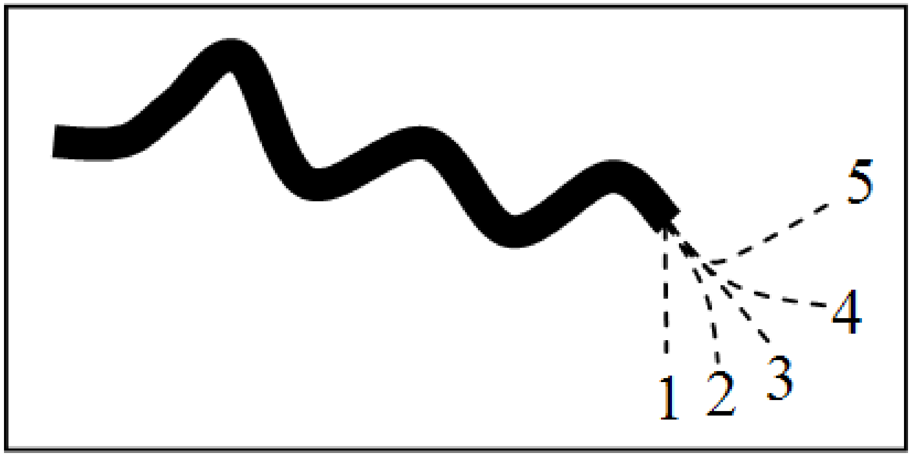
a) 1

b) 2

c) 3

d) 4

e) 5



Which one of the following terms is used to indicate the natural tendency of an object to remain at rest or in motion at a constant speed along a straight line?

a) velocity

b) equilibrium

c) acceleration

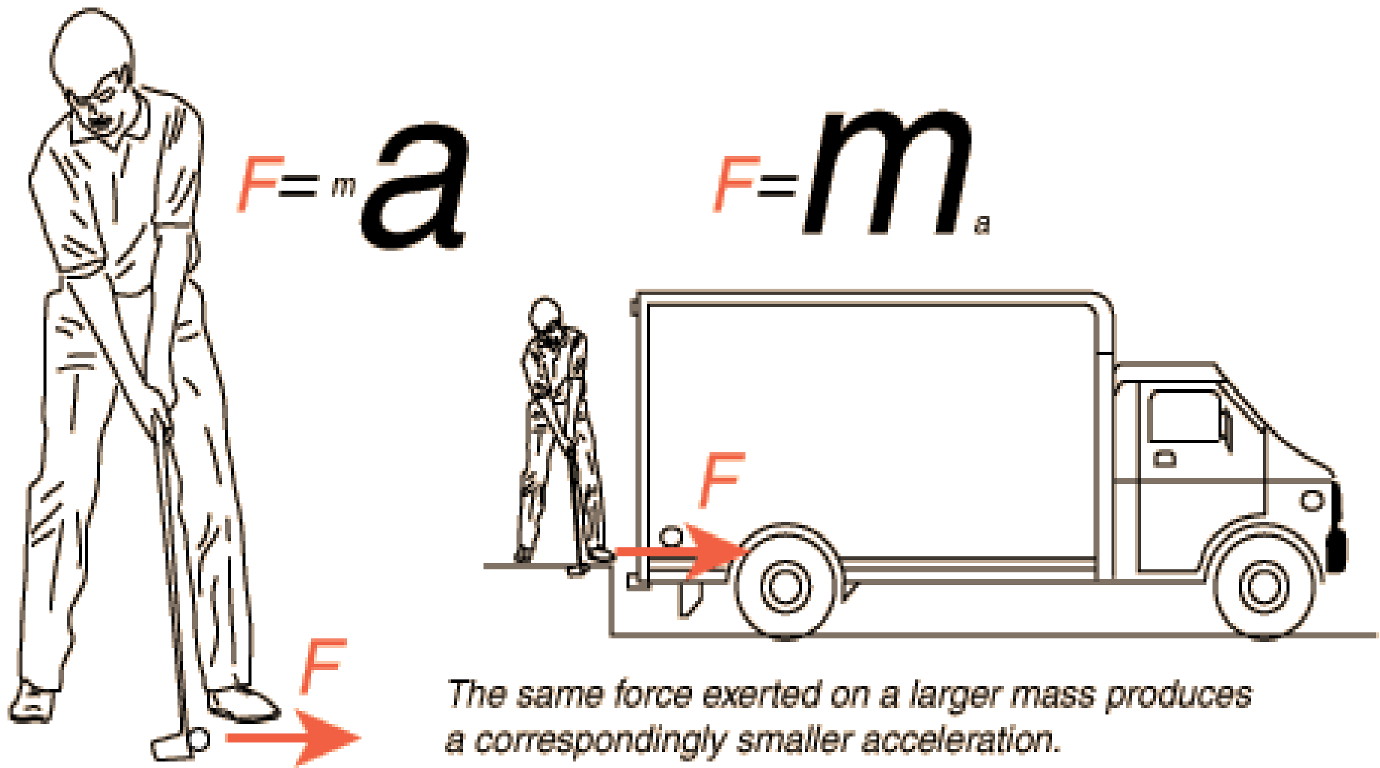
d) inertia

e) force


DADDY'S HOME
I SAY! THAT FALLING APPLE HAS MADETH ME REALIZE SOMETHING...
I'M HUNGRY!
NEWTON'S FIRST LAW OF MOTION
An object in motion tends to stay in motion.
An object at rest tends to stay at rest...
Z
unless acted upon by an object in motion.
NEED HELP, HON?
NO, SIT! I'VE GOT IT!

Newton's second law : F = ma

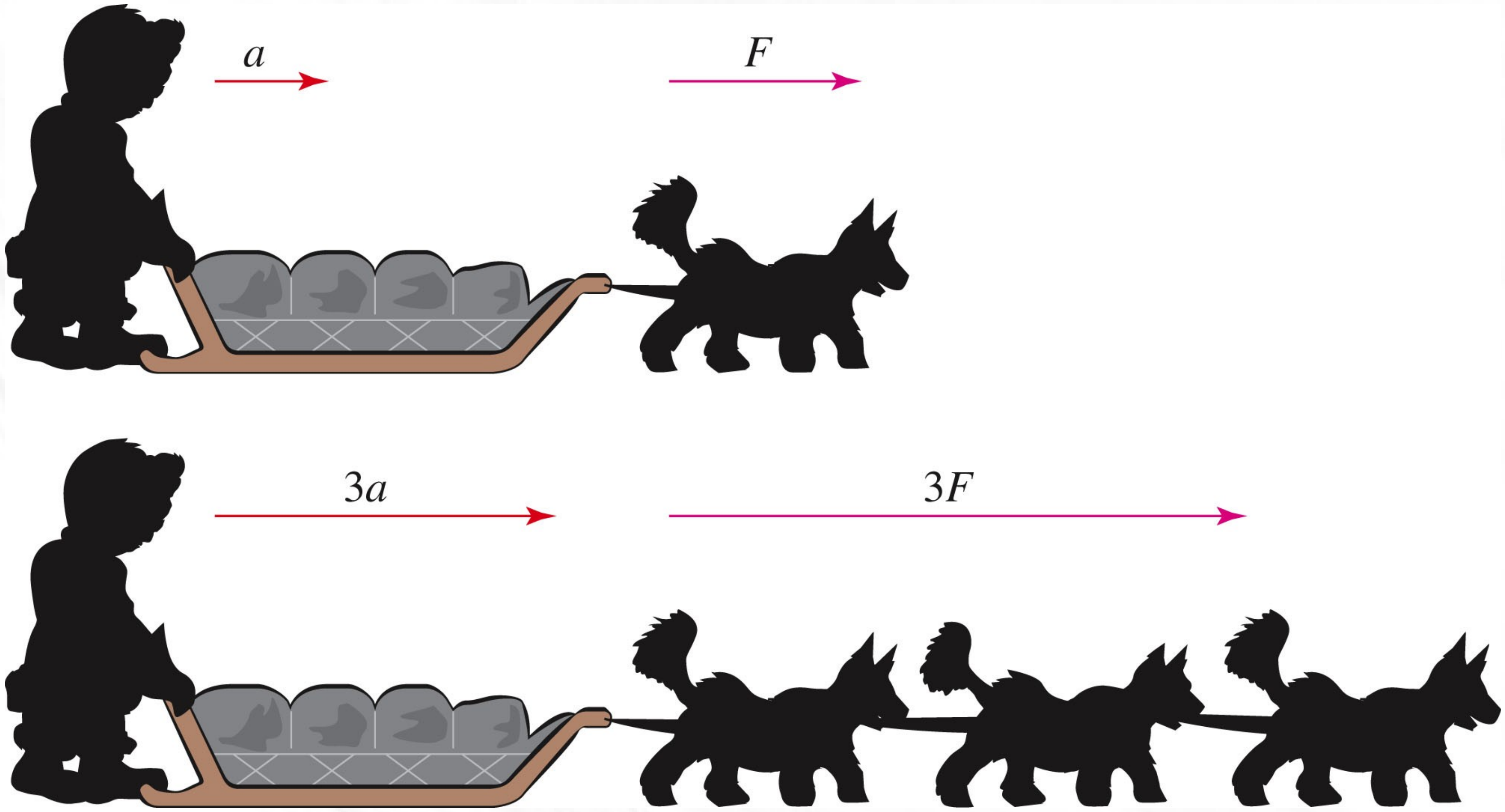
Push/pull = change in velocity (magnitude or direction or both)
but the change depends on the mass !!!
Force in newtons, mass in kg, acceleration in m/s/s



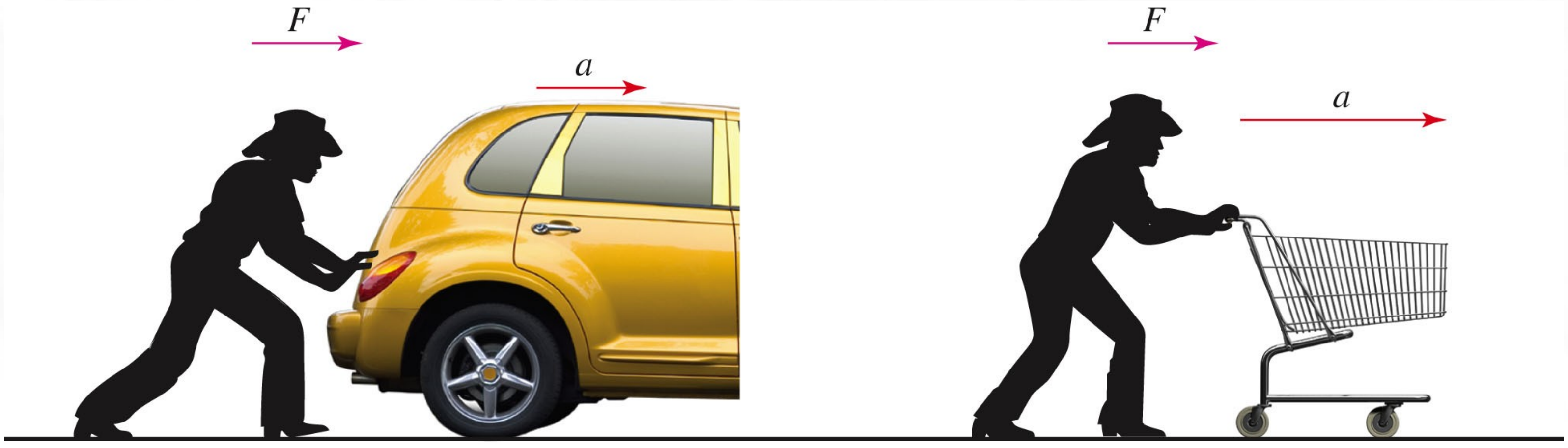
The same force exerted on a larger mass produces a correspondingly smaller acceleration.

Exploration of physical sciences Newton's law
Sims https://phet.colorado.edu/en/simulation/forces-and-motion-basics

Net Force = mass x acceleration
(Newtons) (kg) (m/s/s)



For the same mass , the acceleration is proportional to the net force



For the same force, the acceleration is inversely proportional to the mass. Acceleration = Fnet/mass

Complete the following statement: The term net force most accurately describes

a) the inertia of an object.

b) the quantity that causes displacement.

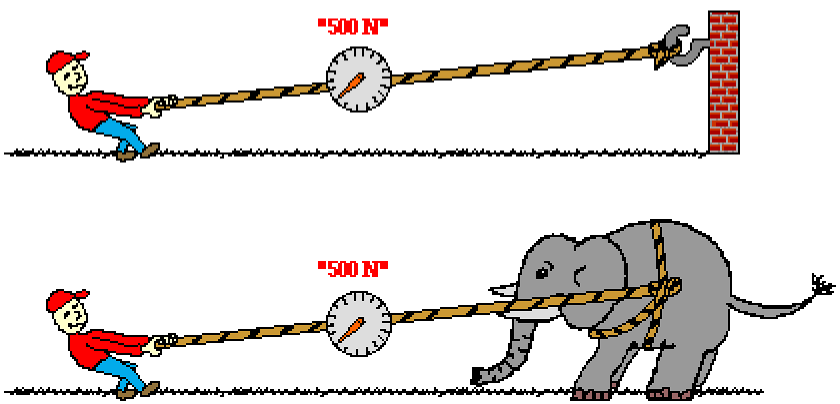
c) the quantity that keeps an object moving.

d) the mass of an object.

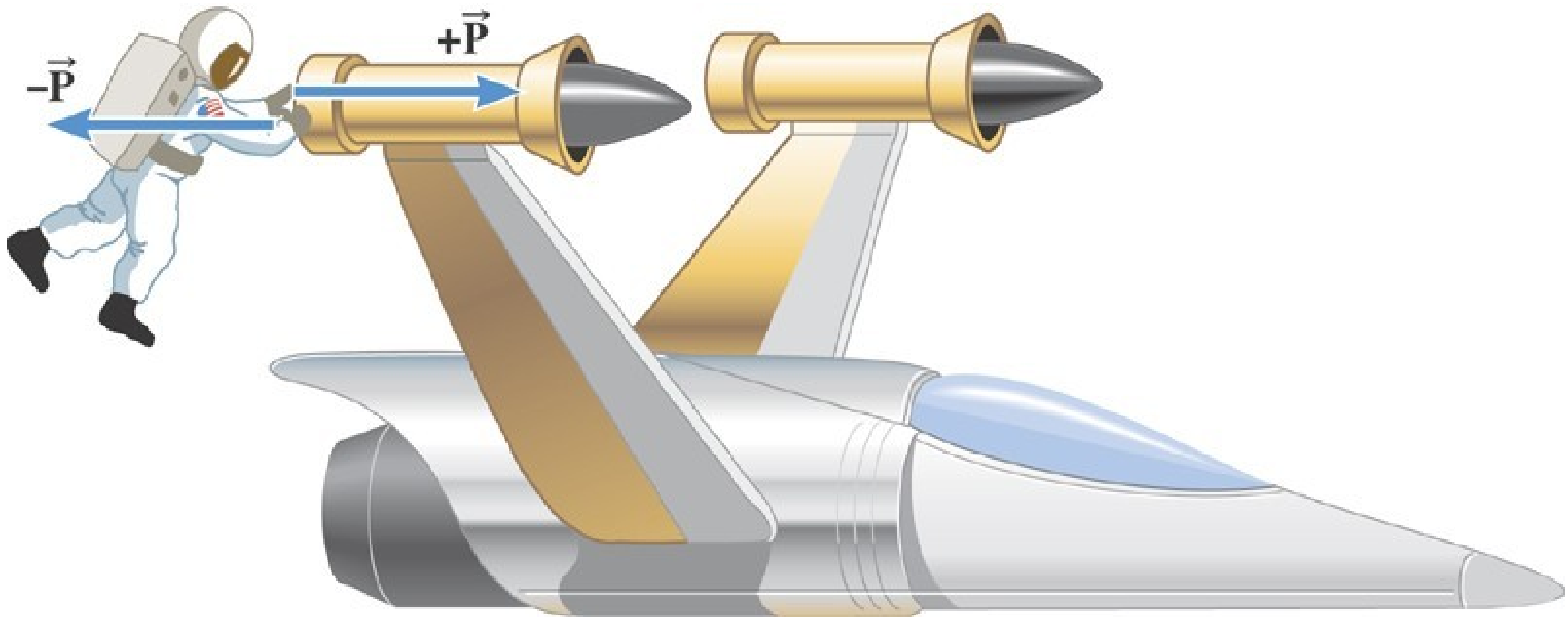
e) the quantity that changes the velocity of an object.

Newton’s Third Law of Motion

Whenever one body exerts a force on a second body, the second body exerts an oppositely directed force of equal magnitude on the first body.



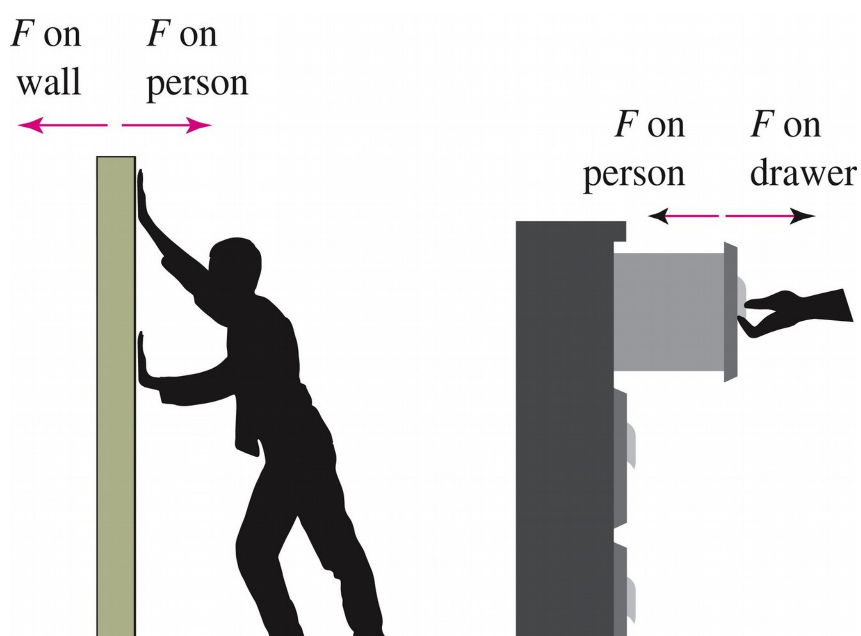
Demo with the scales



m **a** = Push = **M** a

Newton’s third law of motion

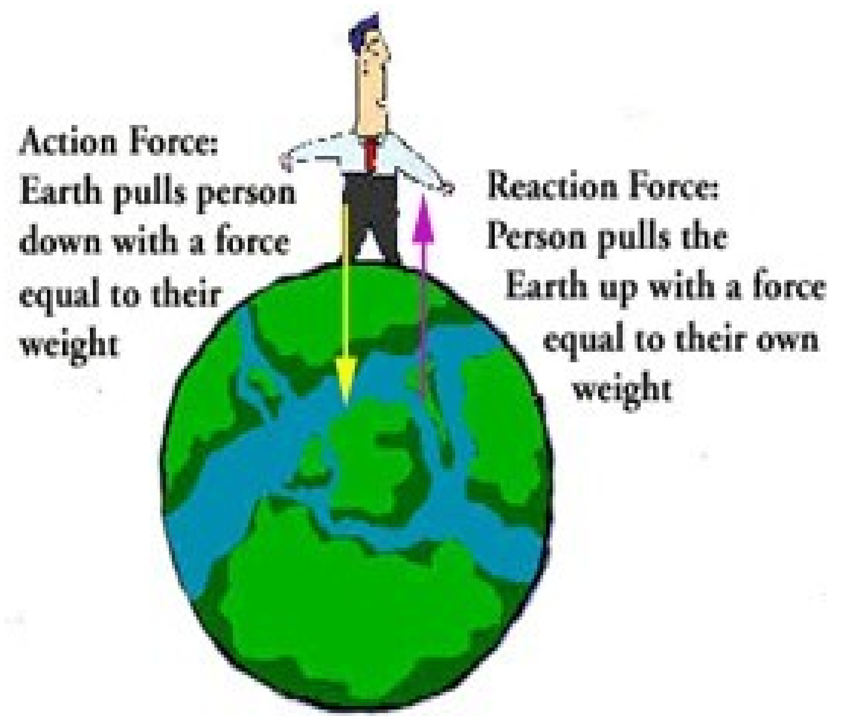
- **Newton’s 3rd Law of Motion** states that forces always occur in pairs:
  - When one object exerts a force on a second object, the second exerts an equal and opposite force on the first.



Newton's third law of motion, cont'd

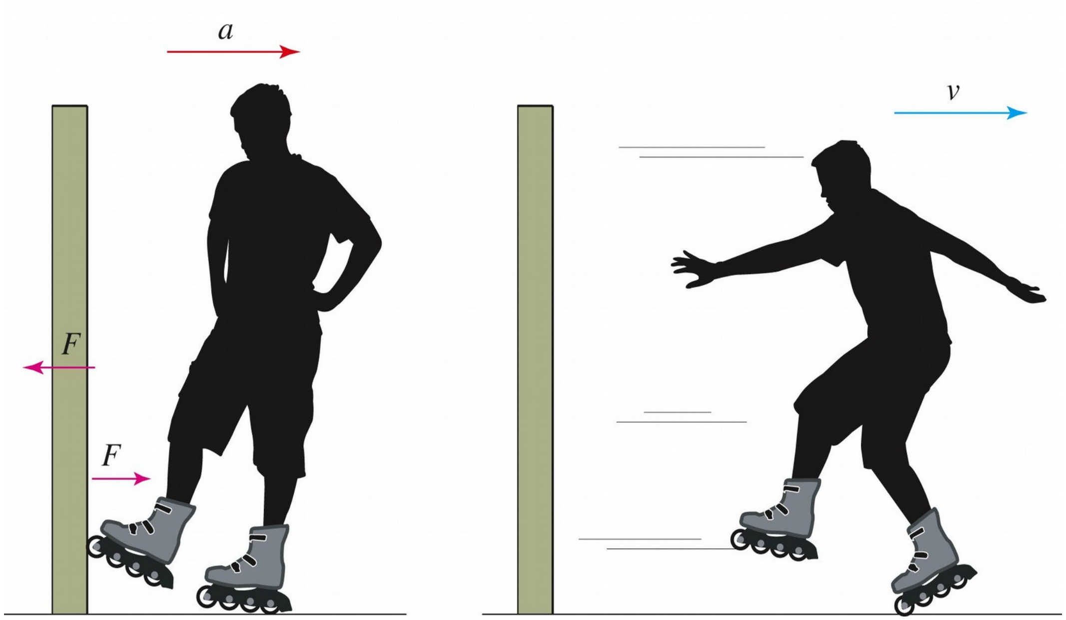
- If object A exerts a force on object B, then object B exerts an equal force in the opposite direction on A:
- $F_{A\ on\ B} = - F_{B\ on\ A}$

When you fall down, you feel the Earth exerting a force on you but you also exert that same force on the Earth.



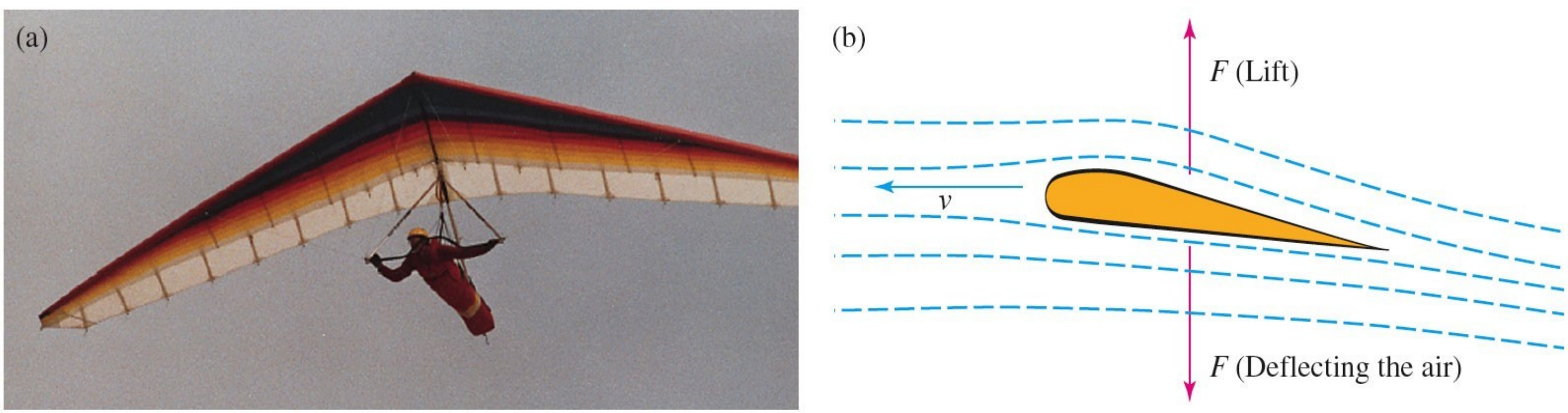
Newton’s third law of motion, cont’d

- Think about pushing off against a wall.
  - You push against the wall.
  - The wall pushes back.
  - If the wall is weak, it might fall down.
  - If not, you move away.

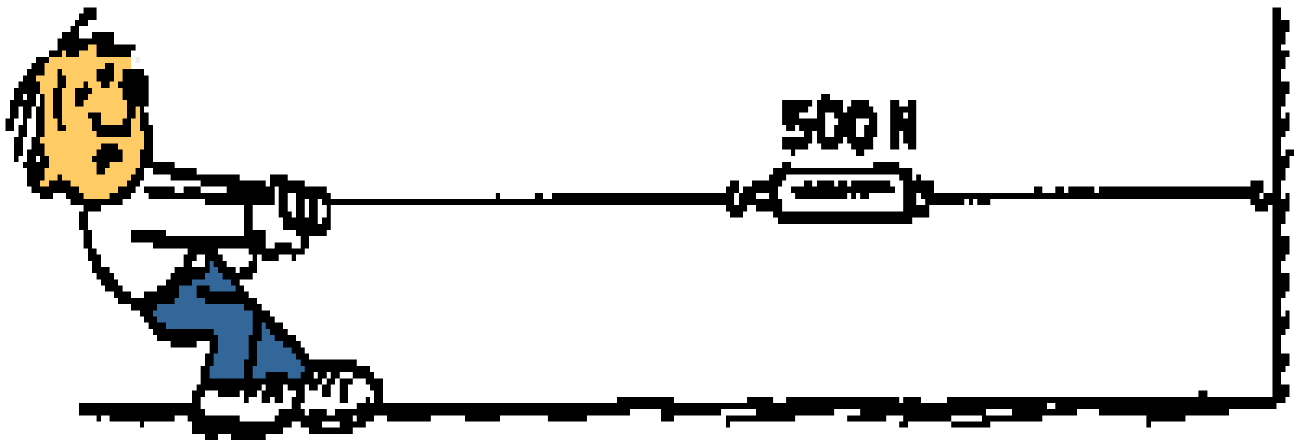


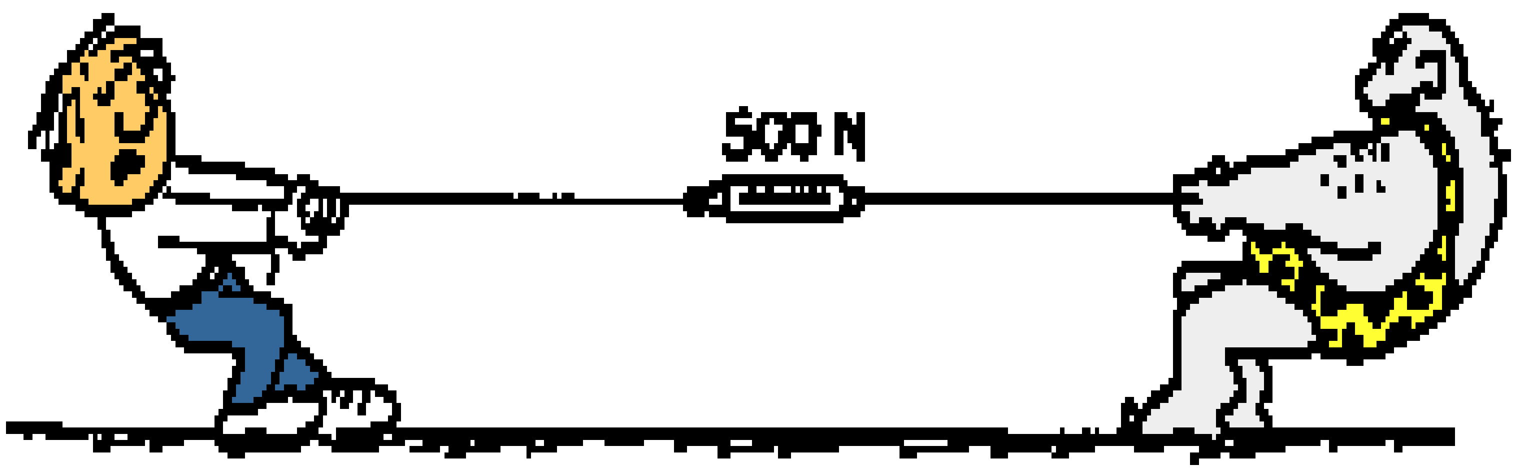
Newton’s third law of motion, cont’d

- Consider an airplane’s wing.
  - Due to the angle of attack, the air impacts the bottom of the wing.
  - The wing pushes the air out of the way.
  - The air pushes back and provides some lift.



NEWTON's THIRD LAW





$$-\,m\,A \qquad = F = \qquad M\,a$$

1) a truck and a smart collide head front.
A) they both experience the same force
B) the truck experiences more force
C) the smart experiences more force
D) not enough information

What about the acceleration and damage ? (change in velocity)

2) A little girl is playing tug of war with her dad.
A) she exerts the greatest force
B) he exerts the greatest force
C) They experience the same pull

Is the acceleration the same ? (who experiences a change in speed)

3) An apple is placed on a table. The Earth pulls on the apple. What is the reaction ? Consequence?

4) A hammer hits a nail. What is the reaction ? Consequence?

5) The blades of a helicopter push the air down. What is the reaction. Consequence ?

6) while you walk you push the ground back ward (possible if friction)
What is the reaction ? Consequence?

$m\,\mathbf{a}$ = same force = $\mathbf{M}\,a$

How Newton's third law can explain
The lift of the space shuttle ?

What happen to your shoulder if you shoot using a riffle ? To spare your shoulder, is it better to use a heavy riffle or a light one?

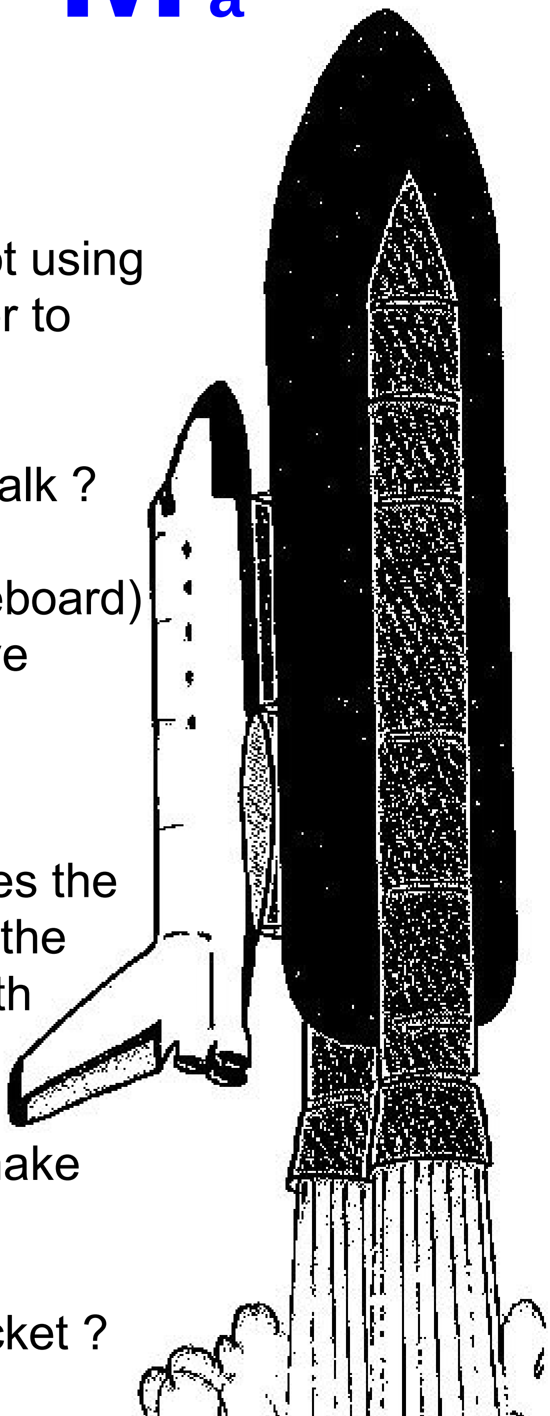
How Newton's third law can explain the walk ?

If you stand on the ground (not on a skateboard) and you push the wall, why don't you move back ? What is the other pair of forces involved ?

In a cowboy movie, the good guy punches the bad guy who goes flying away. Of course the good guy stays steady. What is wrong with that ?

Also, when a bullet hit a person, does it make sense to see the guy flying off ?

How to relate newton's third law to the rocket ?



DURING A COLLISION THE FORCE and THE TIME " felt" BY THE 2 OBJECTS is the same BUT NOT THE ACCELERATION (or CHANGE OF SPEED= DAMAGE).

They both feel the same force
But Baloo has a larger mass He does not move as much as Mowgli. Change in speed Is larger for Mowgli.

$$m\ a = F = -\ M\ a$$

Same because Acceleration =change of speed over time. Time of collision is the same

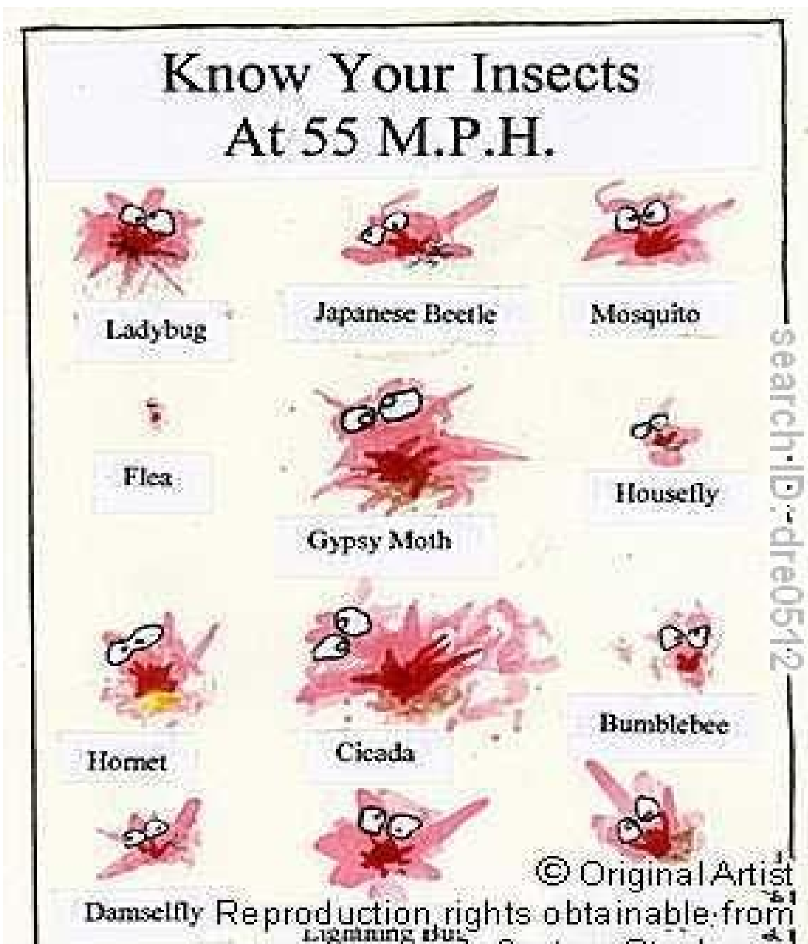
Same force→
BIG MASS = small change in speed
Small mass=BIG CHANGE IN SPEED

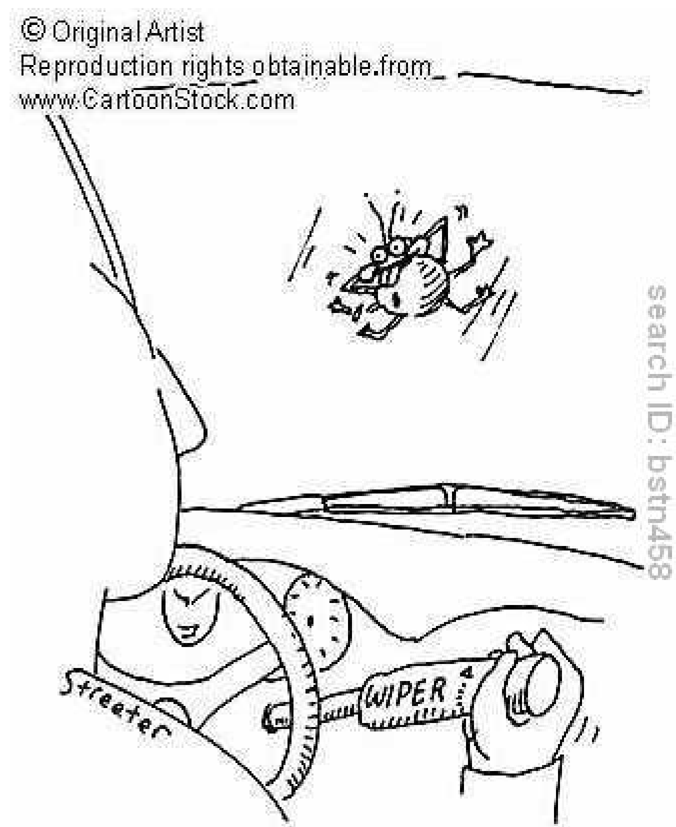
$$m\ \Delta V = F/time = -\ M\ \Delta V$$

You are traveling in a bus at highway speed on a nice summer day and an unlucky bug splatters on the front window.

With Newton's third law in mind , Compare to the force that acts of the bug , how much force acts of the bus ?

Which undergoes the greater acceleration ? Which therefore suffer the greater damage ?





A cell phone is sitting on a desk. Which one of the following is the reaction force to the cell phone's weight on the desk?

a) the gravitational force on the cell phone

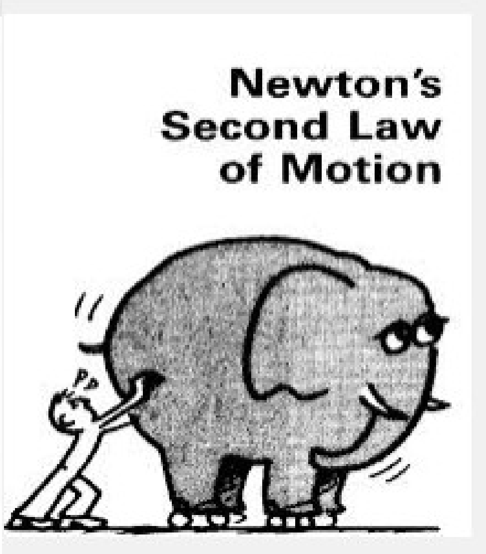
b) the gravitational force on the table

c) the normal force of the Earth on the table

d) the normal force of the cell phone on the table

e) the normal force of the table on the cell phone

Newton's second law:

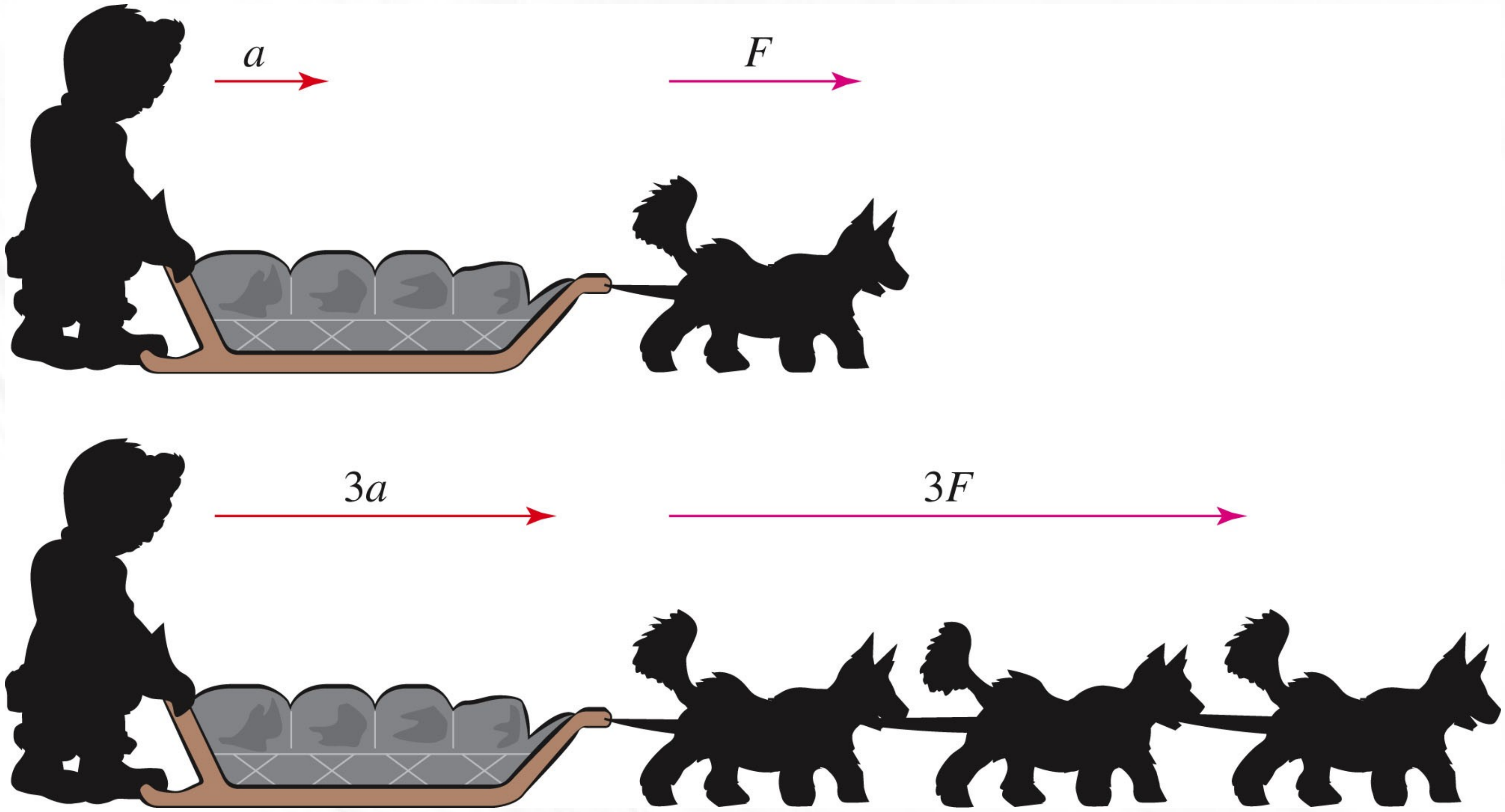


1) F=ma
2) impulse J
2) Newton’s law in parts in 2D

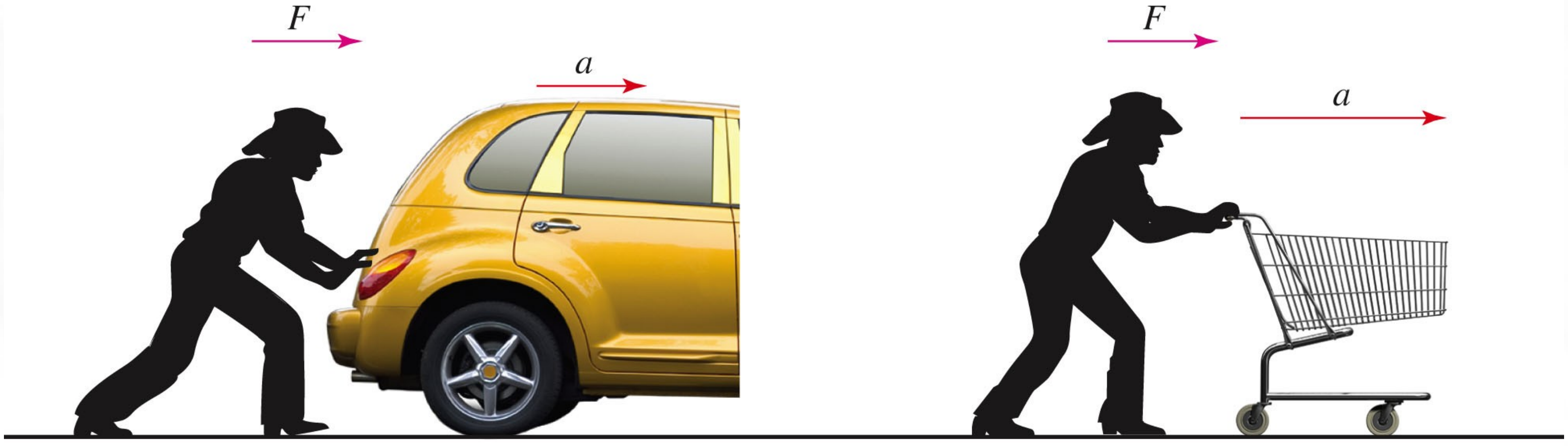
Newton's second law of motion can be formally stated as follows: The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force,
and inversely proportional to the mass of the object

http://www.physicsclassroom.com/class/newtlaws/Lesson-3/Newton-s-Second-Law

Net Force = mass x acceleration
(Newtons) (kg) (m/s/s)



For the same mass , the acceleration is proportional to the net force



For the same force, the acceleration is inversely proportional to the mass. Acceleration = Fnet/mass

Newton's second law: different approach. Let's write the la the same way Newton wrote it in his Principia.

BIG IDEA:

To change the motion of an object, a force has to be applied During a time t. Change in motion means change in velocity (direction or magnitude).

Try to translate that statement in a mathematical relationship.

(force F during time t means change in velocity ΔV)

So ΔV **=**

.

But wait !

the change in velocity is inversely proportional to the mass (inertia).

So, modify the relationship so the change in velocity is inversely proportional To the mass (inertia)

BIG IDEA: (Newton's second law)

If you apply a force F during a time t, the state of motion Changes, The velocity increases by ΔV

Like wise, if an objects undergoes a change in motion that's because it is acted upon by a force during a time

$$\dot{F}\Delta t = m\Delta V$$

$$J = F\Delta t$$

Impulse = change in momentum

The quantity $F\Delta t$ is called the impulse and is noted J in your book.

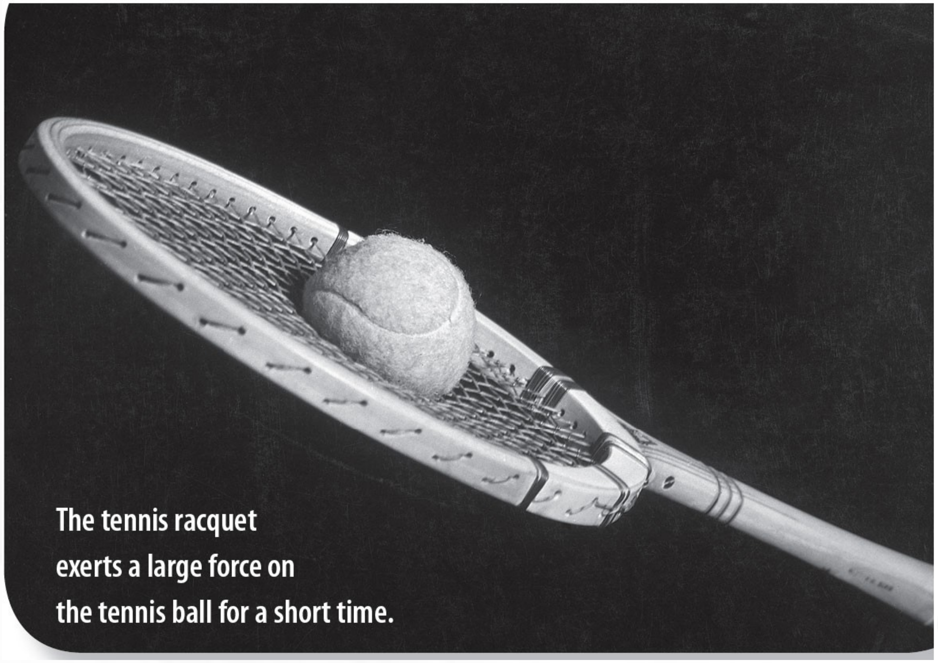
It is a vector because F is a vector. Units are N.s

The quantity $m\Delta V$ quantifies the change of motion. It is called the change In momentum.

It is a vector because F is a vector. Units are kg. m/s

Example

Let's estimate the average force on a tennis ball as it is served. The ball's mass is 0.06 kg and it leaves the racquet with a speed of 40 m/s. High-speed photography indicates that the contact time is about 5 milliseconds.

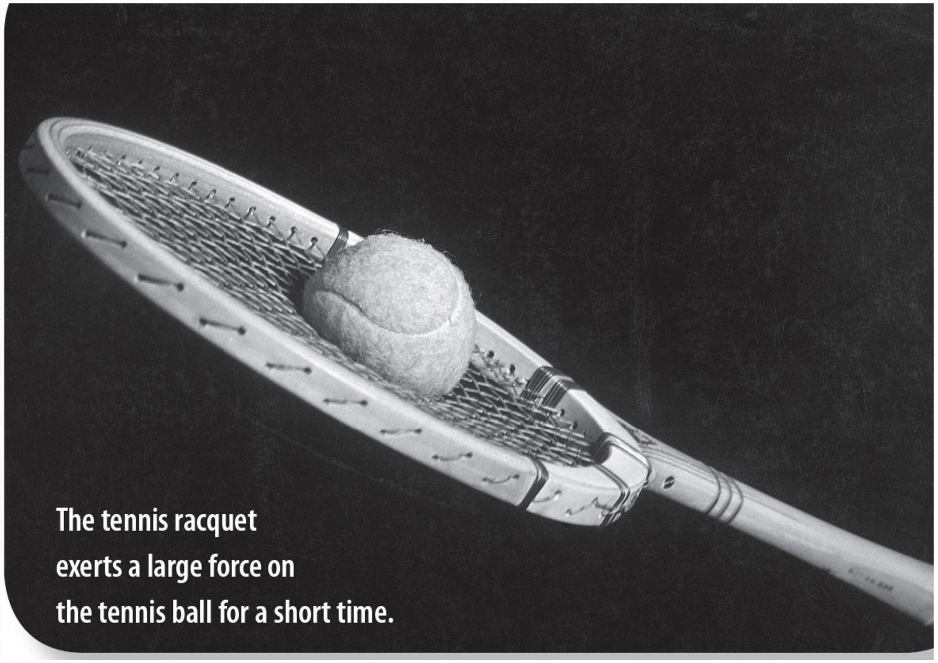

The tennis racquet exerts a large force on the tennis ball for a short time.

So the velocity of the ball increases from 0 to 40 because
There is a force applied to it during a time 0.005s

$$F\Delta t = m\Delta V$$

$$F\Delta t = m\Delta V$$

Let’s estimate the average force on a tennis ball as it is served. The ball’s mass is 0.06 kg and it leaves the racquet with a speed of 40 m/s. High-speed photography indicates that the contact time is about 5 milliseconds.



$0.06(40-0)= F\ (0.005)$

$F=480N$

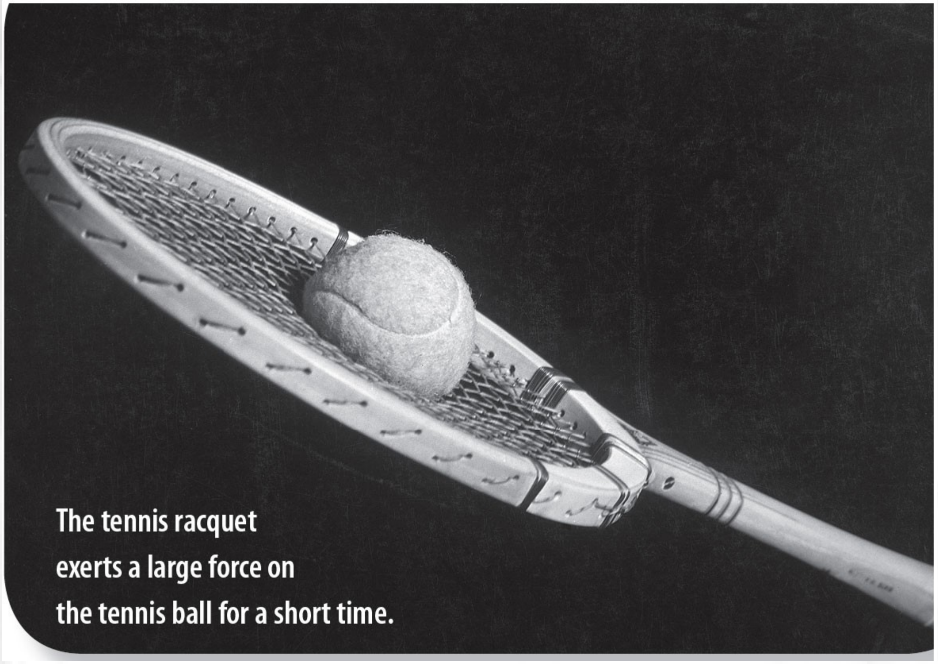
(about the weight of 48kg or 96pounds)

Why do you think you should have a good follow through?

You increase the time of contact for the same force F (same muscle). What happens to the speed of the ball ? (that is to its change of momentum ?)

Why a pitcher keep the baseball as long as possible when throwing ?

- This tells why we must exert a force to stop an object or get it to move.
  - To stop a moving object, we have to bring its momentum to zero.
  - To start moving an object, we have to impart some momentum to it.

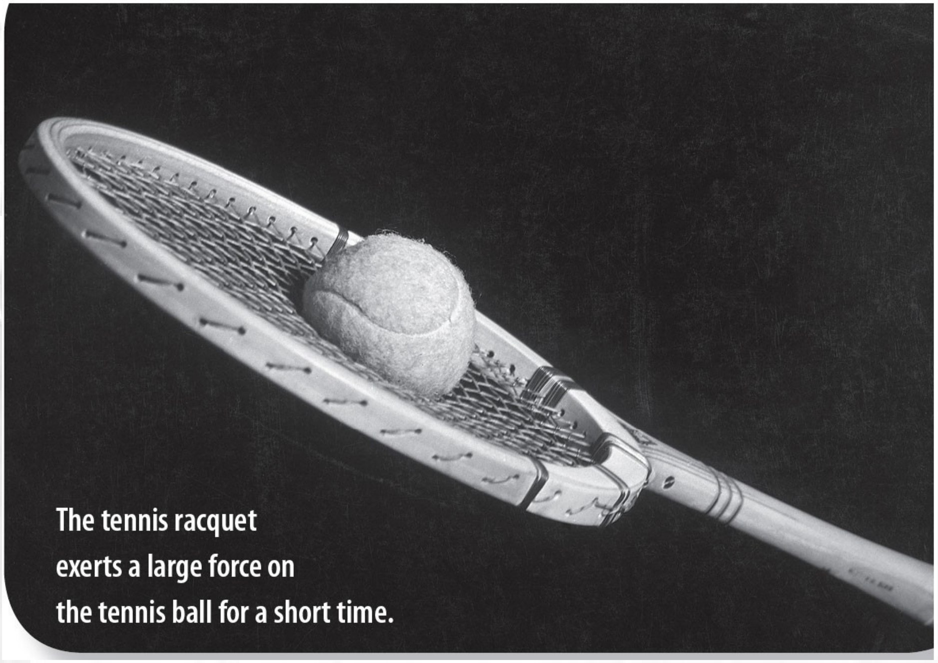


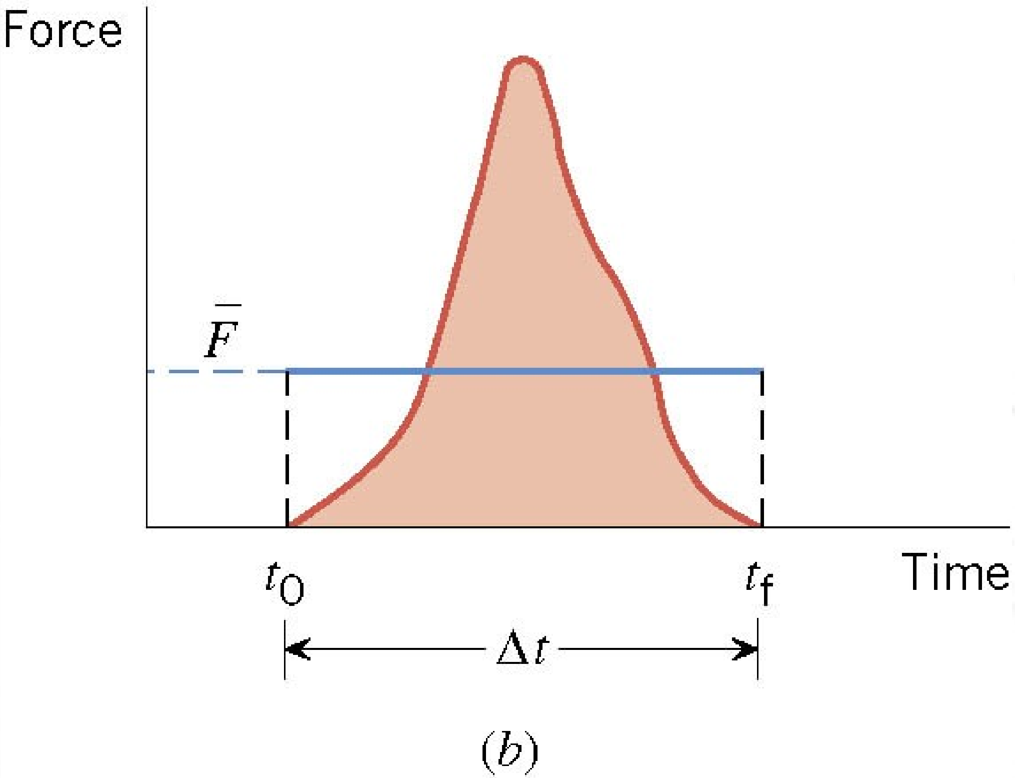
In reality the force applied to the Ball by the tennis is not constant . It increases and decreases. The formula is in fact:

$$m\Delta v = \overline{F}\Delta t$$

Change in momentum = impulse

$$m\Delta V = \overline{F}\Delta t$$





$\overline{\boldsymbol{F}}$ Is the average force applied during the time $\boldsymbol{\Delta t}$

IMPULSE-MOMENTUM THEOREM

And if more than 1 force act on an object, we need
To find first the net force before using the theorem
Called the impulse-momentum theorem;

When a net force acts on an object, the impulse of this force is equal to the change in the momentum of the object

impulse

$$\left(\sum \overline{F}\right)\Delta t = m(V_{\mathbf{f}} - V_i) = mV_{\mathbf{f}} - mV_i$$

final momentum

initial momentum

Momentum is mass x velocity. We will see that in more details next unit.

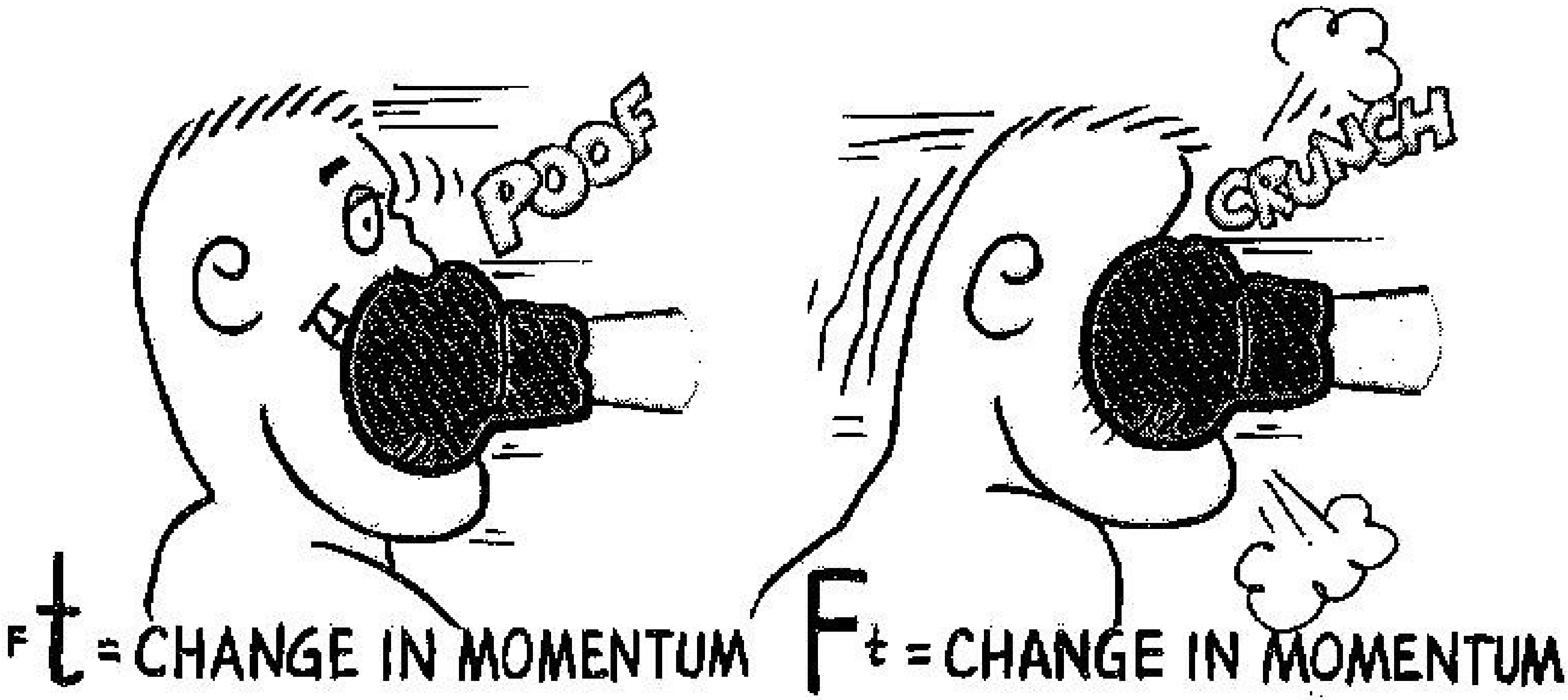
BUT LETS GO BACK TO THE BIG IDEA behind this formula:

- It also tells us that we can change the motion using various forces and time intervals:

$$F\Delta t = m\Delta V$$

  - Use a large force for a short time, or
  - Use a small force for a long time.

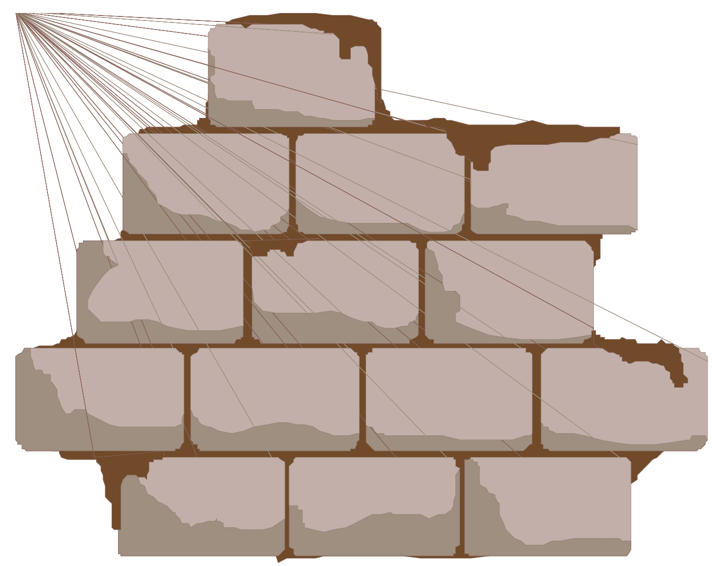
Change in motion = change in momentum



SO WHY DO YOU THINK a boxer that is getting punched needs to " roll over " ?

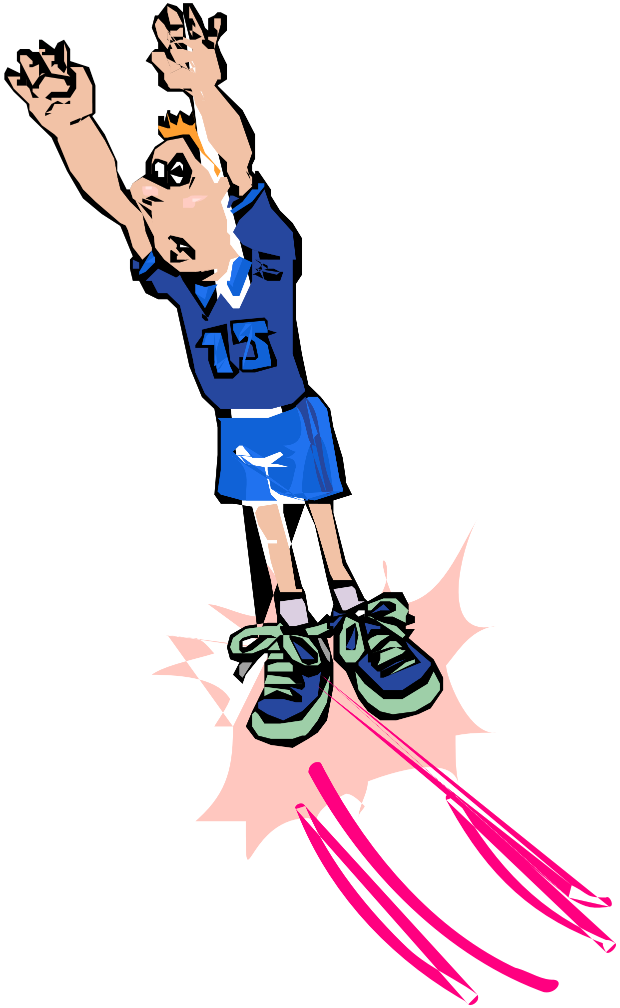
He moves away when the glove hits versus staying put ?

In both cases, the **change in momentum is the same**



A truck can be stropped by a haystack
Or by a brick of wall. The change of motion
Is the same. But what about time and force?
Which situation would you prefer ?

$$m\Delta v = \overline{\Large\mathrm{F}}{\scriptstyle\Delta t} \quad or \quad m\Delta v = {\scriptstyle\overline{\mathrm{F}}}\Large\Delta t$$



When you jump and you come
Back to the ground,
why don't you keep the
Legs stiff instead of bending them ?

Change in motion means a force is applied to the ground so
The ground applies the same force on the jumper.

1 To slow down a car, a braking force of 1 200 newtons is applied for 10 seconds. How much force would be needed to produce the same change in velocity in 6 seconds ?

2 A frictionless wagon going at 2.5 meters per second is pushed with a force of 380 N, and its speed increases to 6.2 meters per second in 4.0 seconds. What is its mass?

3.An average force of 300N acts for a time of 0.04s on a golf ball.
A)What is the magnitude of the impulse acting on the golf ball ?
B)What is the change in the golf's momentum ? (change in momentum)
C)What is the force the golf's fall acts on the club ?

4. A force of 35N acts on a ball for 0.2s . the ball is initially at rest:
A)What is the impulse on the ball ?
B)What is the change in momentum

5. A force of 35N acts on a ball for 0.2s . the ball is initially at rest:
A)What is the impulse on the ball ?
B)What is the change in momentum

6.A 0.12kg ball traveling with a speed of 40m/s is brought to rest in a catcher's mitt.
What is the size of the impulse exerted by the mitt on the ball ?
What is the change in momentum ?

7. A 60kg front-seat passenger in a car moving initially with a speed of 18m/s (40mph) is brought
To rest by an air bad in a time of 4.0s .
A)What is the impulse acting on the passenger ?
B)What is the average force acting on the passenger in this process ?

8. What force is needed to accelerate a 60kg wagon from rest to 5m/s in 2 s?

9. more challenging:A spacecraft has 2 rockets engines, one producing a thrust of 300N and the other 750N. Firing the Smaller engine for 10s speeds the ship from 80m/s to 95m/s and the large engine for 12s, How fast is the ship then going ?

10. more challenging. A spacecraft is going 350m/s; a retro rocket that provides a force of 520N for 10s slows it down to 300m/s. Then another retro rocket fires , with a force of 130N for 4s. How fast is the craft then going.

11. A net force of 20N acting on a wooden block produced an acceleration of 4m/s/s for the block. What is the mass of the block?

12. A pulled tablecloth exerts a frictional force of 0.6N on a plate with a mass of 0.4kg. What is the acceleration of the plate ?

13. A single force of 40N acts upon a 5kg block. What is the magnitude of the acceleration of the block ?

14. If your weight is 600N
A) What is the mass in kg
B) what is the weight in lbs

Revisiting uniform circular motion

In a previous unit we saw that he centripetal acceleration is v^2/R
.v is the speed of the object moving in a uniform circular motion.
If there is an acceleration → centripetal force that keeps the object
Along the path.

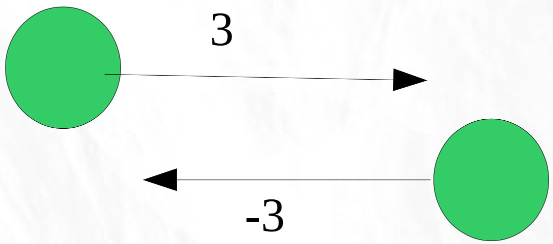
Newton’s second law: F = ma → $\mathbf{F = m\,v^2/R}$

1) A 2kg rock is tied to a string 50cm long and spun around in a horizontal circle. If the string will break when the tension exceeds 250N , what is the greatest speed The rock can have without breaking the string ?

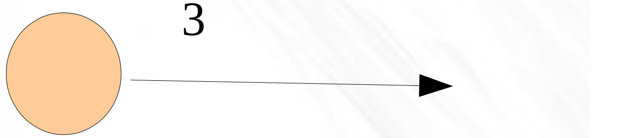
2) A bicycle and rider, with a combined mass of 50kg, are traveling at 5m/s. If they Are going in a circular path whose radius is 30m, how much force is the force Acting on the tired? (static frictional force).

3) The centripetal force due to gravity keeps satellite in orbit. The force is mass x g. g is 9.8 on Earth but g decreases with altitude. Suppose a satellite is at an Altitude of 12,000km (so radius R = 12,000 + radius Earth = 18,400 km about). At that altitude we have g = 1m/s/s about.
Use F = mg = centripetal force ($\mathbf{F = m\,v^2/R}$) to find the orbital speed of the satellite
Hint: the mass are crossed out. Extract the speed v.

Consider a green bouncing ball that bounces and an orange ball that sticks. The wall " feels a force "



Suppose m = 1kg
So it is easier to compute.
Change = final - initial



Both undergo a change in momentum
And they both have the same initial velocity.

Which one undergo the largest change in motion $m\Delta V=m\ (V2-V1)$
(change in momentum)
This one applied the largest force to the wall.
(change in momentum = Impulse = force x time)
You can suppose V1=3
V2=-3 for green and v2=0 for orange

$m\Delta V$ =m(3 - (-3)) = ______ (with m =1)

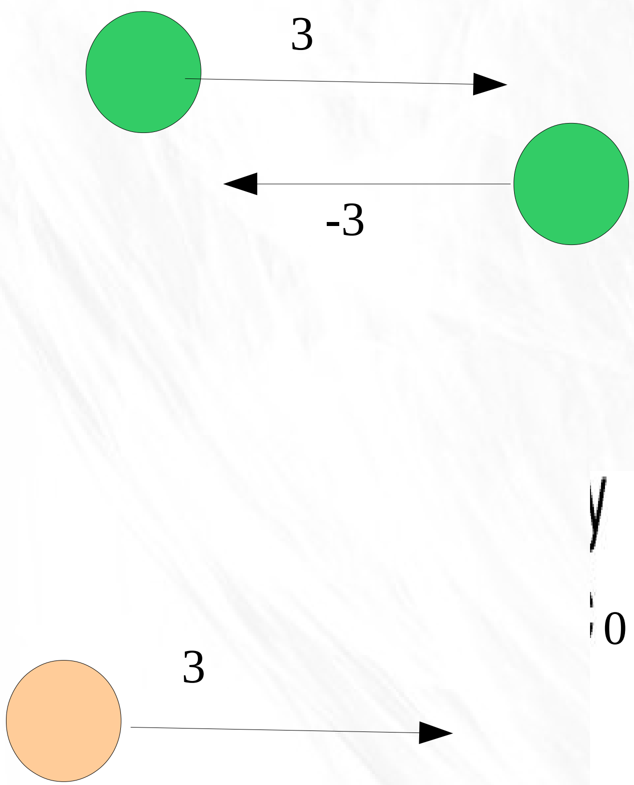
$m\Delta V$=m(3 - 0)= ________ (with m =1)

So which one " feels" the greatest Impulse $J=F\Delta t$?

Consider a green bouncing bal that bounces and an orange ball that sticks:

mΔv=6m=J

mΔv=3m=J/2



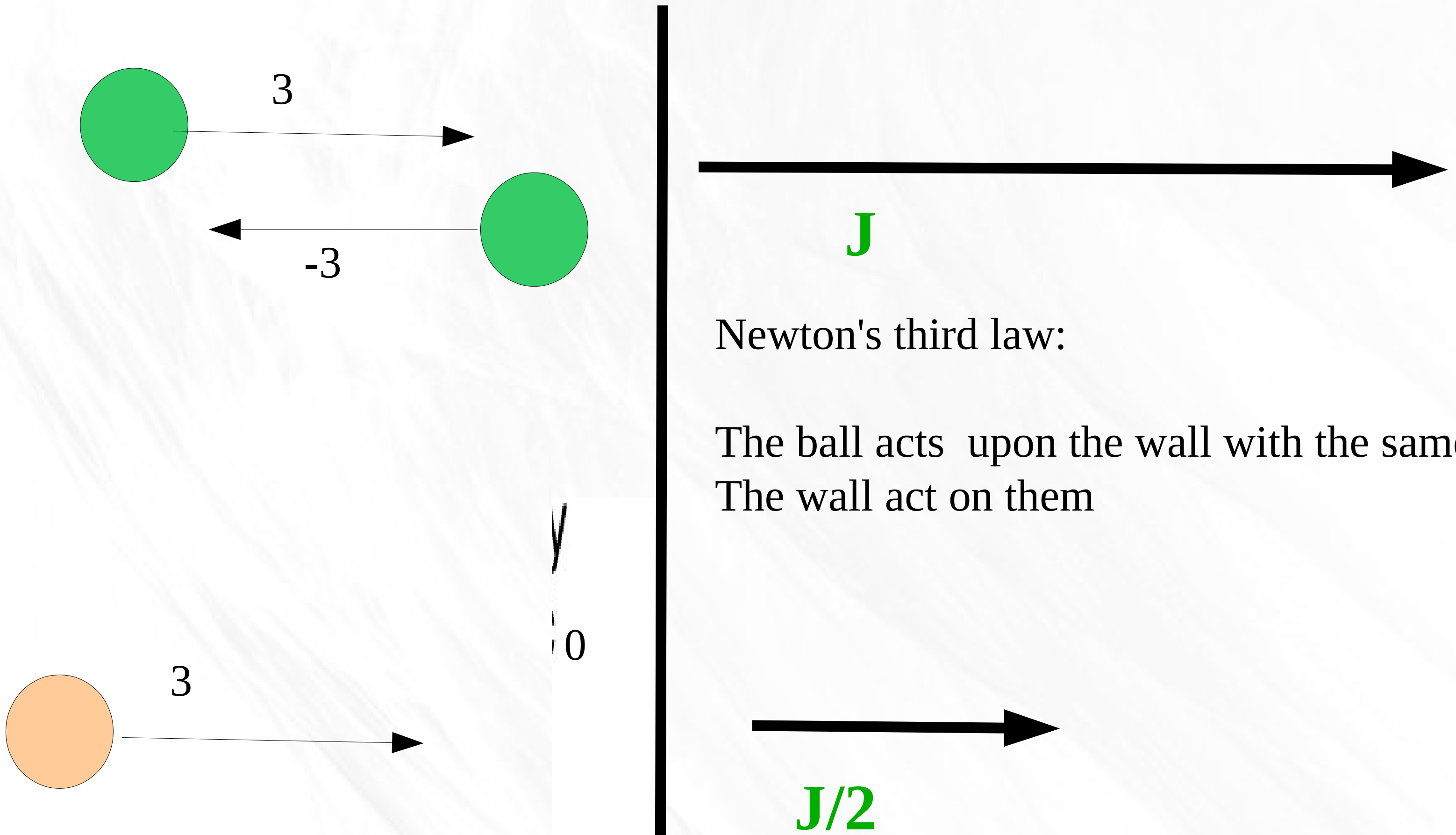
J

The “kick” the green ball “ feels” is half
The force “felt” by the orange one.
The change in motion of the green is
Twice the change in motion of the orange.
You need twice the force to stop the ball
And to move it again.

J/2

Watch: happy sad video

Action-reaction = the wall " feel" the same force F or F/2
Same magnitude but inverse direction.

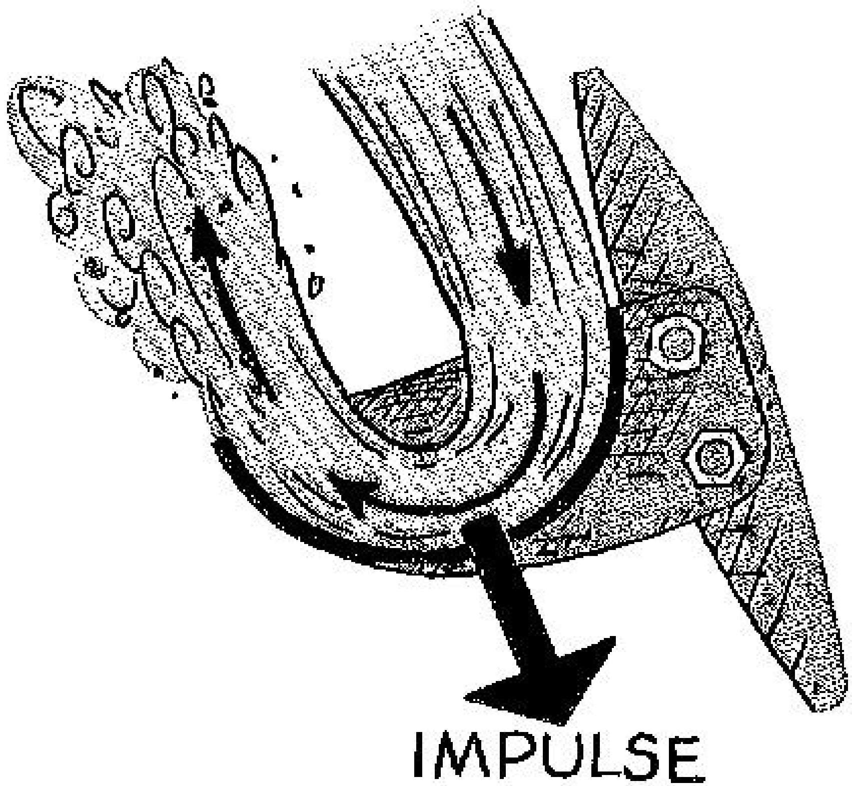


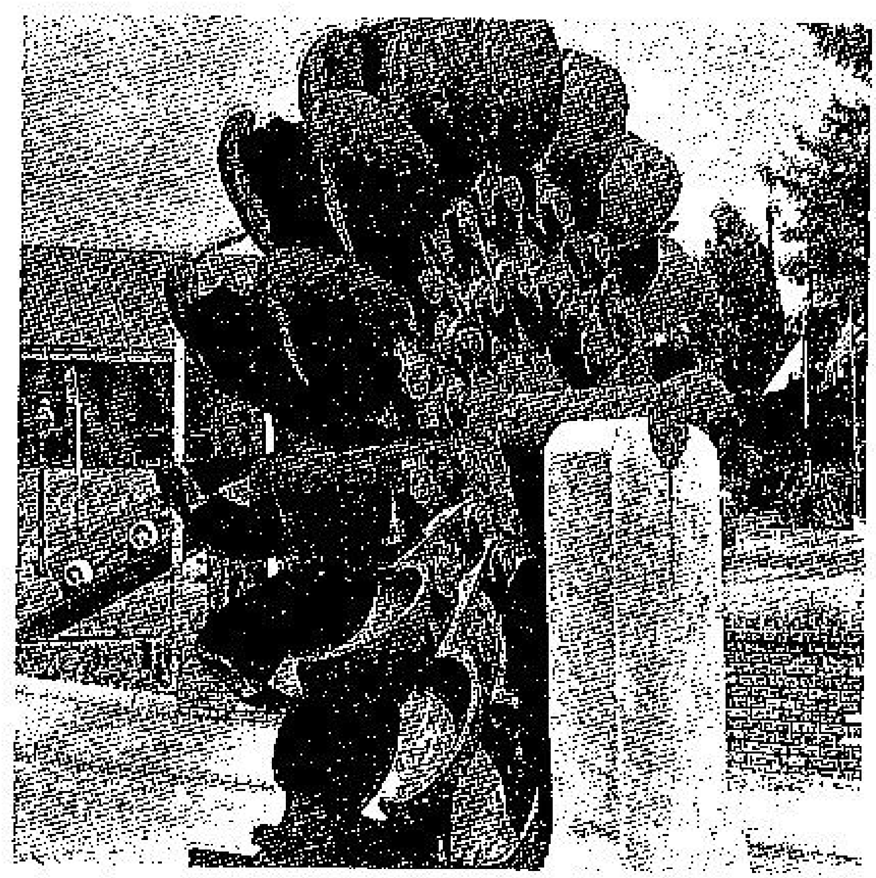
Newton's third law:

The ball acts upon the wall with the same force
The wall act on them

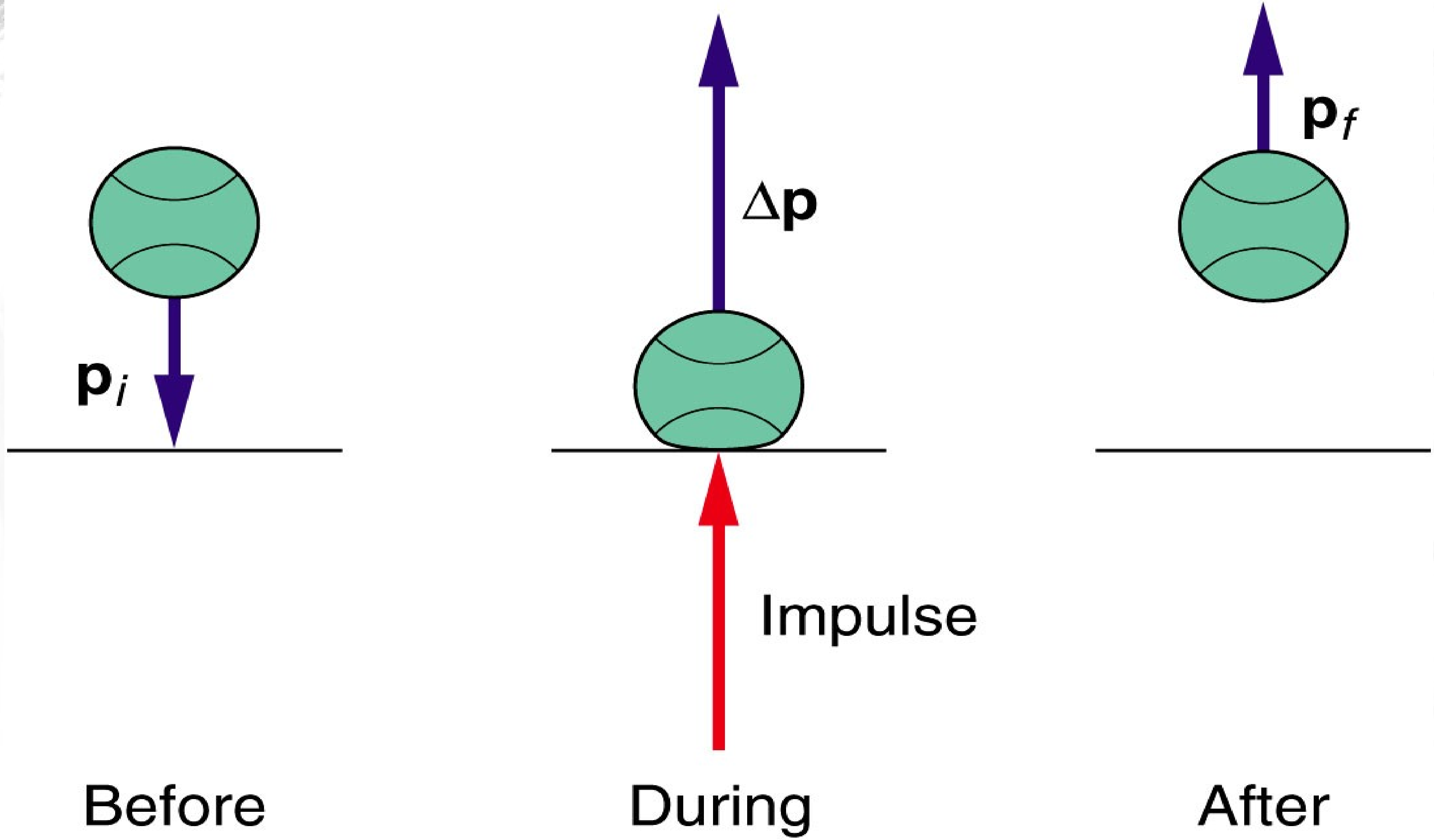
So do you rather be hit by a ball that stick to your forehead
Or by a bouncing ball ? (same mass and same initial velocity).

We suppose the ball is not a bullet that can go inside.





So why do you think this Pelton Wheel was a breakthrough for the Gold miners ? Before they were using flat paddles.
(bouncing =more change in momentum = more impulse)
Source: Paul Hewitt, conceptual Physics.



BOUNCING MEANS FORCE during time t (impulse) = change in momentum
It takes more impulse to catch and throw back a ball than to just stop it.

So why do you think the hand
Of karate girl has to rebound to break
The brick ?

- How does impulse and force differ ?

- What are the two ways impulse exerted on something can be increased ?

- For the same force, which cannon imparts the greater speed to a cannonball: A long cannon or a short one ? Explain

-Why is it a good idea to have your hand extended forward when you are getting Ready to catch a fast-moving baseball in your bare hand?

- Which case illustrates the greatest change in momentum :
(A) a baseball being caught
(B) a baseball being being thrown
(C)or being caught and thrown back ?

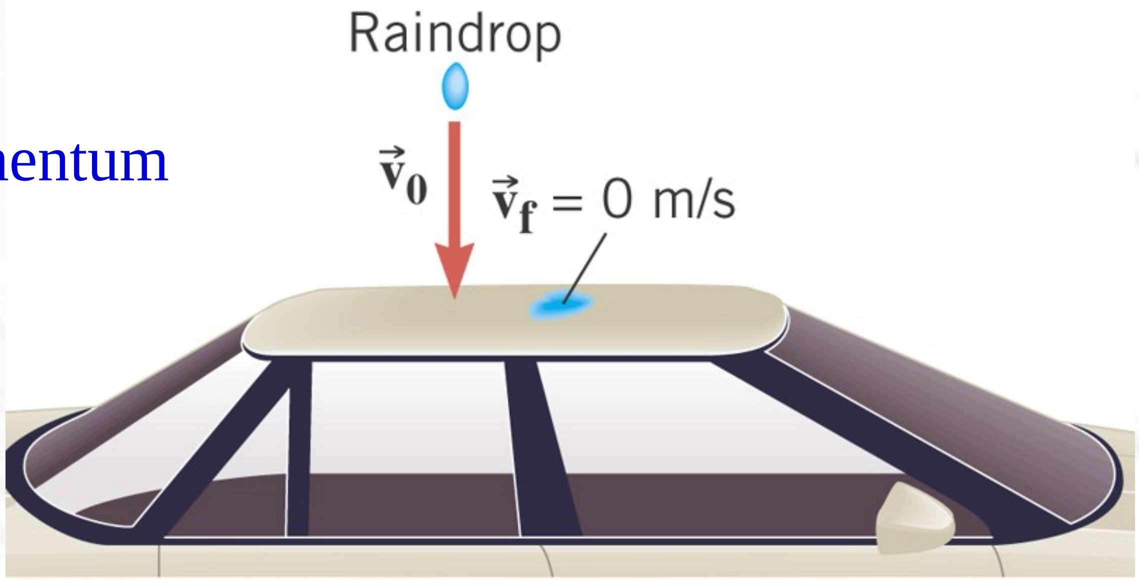
- in the preceding question, in which case is the greatest impulse required?

- why impulses are greater when bouncing takes place

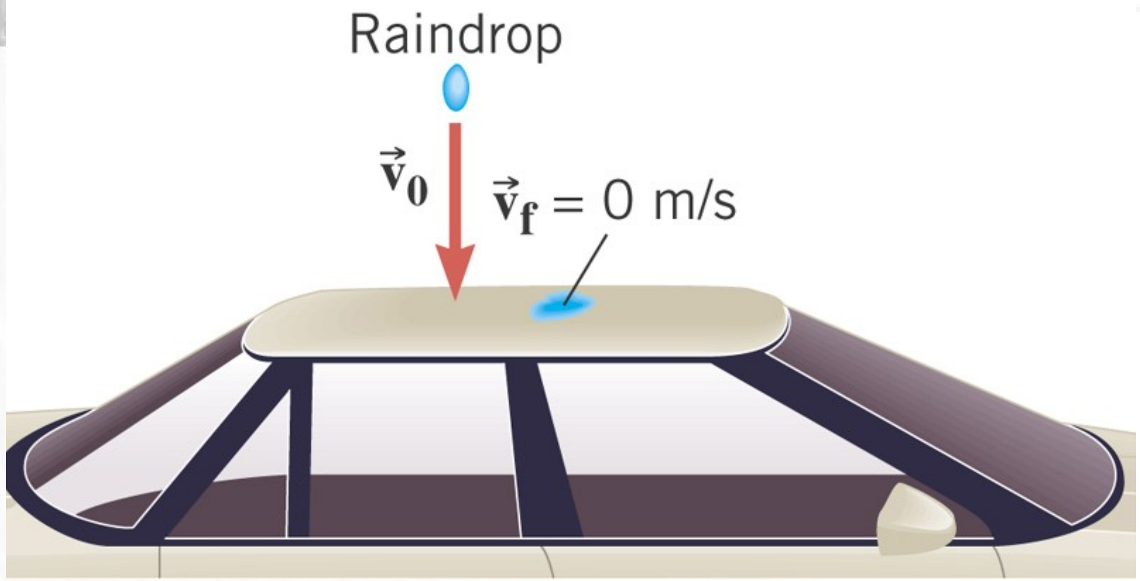
From your book :

Rain comes down with a velocity of -15 m/s and hits the roof of a car. The mass of rain per second that strikes the roof of the car is 0.060 kg/s. Assuming that rain comes to rest upon striking the car, find the average force exerted by the rain on the roof.

Force x time= change in momentum
F t = m (V2-V1)



Neglecting the weight of the raindrops, the net force on a raindrop is simply the force on the raindrop due to the roof.



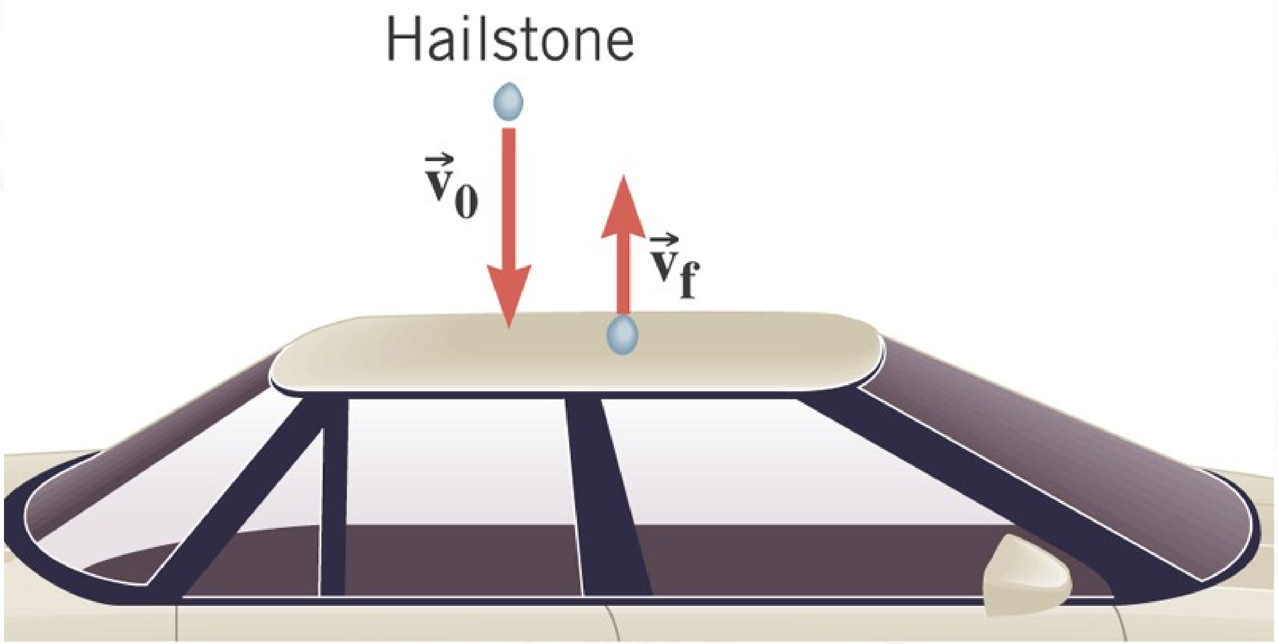
$$\overline{\vec{\mathbf{F}}}\Delta t = m\vec{\mathbf{v}}_\mathbf{f} - m\vec{\mathbf{v}}_\mathbf{o} \quad \Longrightarrow \quad \overline{\vec{\mathbf{F}}} = -\left(\frac{m}{\Delta t}\right)\vec{\mathbf{v}}_\mathbf{o}$$

$$\overline{\vec{\mathbf{F}}} = -(0.060\,\text{kg/s})(-15\,\text{m/s}) = +0.90\,\text{N}$$

Conceptual Example 3 Hailstones Versus Raindrops

Instead of rain, suppose hail is falling. Unlike rain, hail usually bounces off the roof of the car.

If hail fell instead of rain, would the force be smaller than, equal to, or greater than that calculated in Example 2?



1. A ball traveling with an initial momentum of 2.5 km kg/s bounces off and comes back in the opposite
Direction with a momentum of -2.5kg m/s
A)What is the change in momentum of the ball ?
B)What impulse would be required to produce this change ?

2 .A ball traveling with an initial momentum of 4.0kgm/s bounces back in the opposite direction with a
Momentum of -3.5kgm/s
A)What is the change in momentum of the ball ?
B)What impulse is required to produce this change ?

Newton's Second : applications

$$F\Delta t = m\Delta V \qquad F = \frac{m\Delta V}{\Delta t} \qquad F = ma$$

When a net external force acts on an object of mass *m*, the acceleration that results is directly proportional to the net force and has a magnitude that is inversely proportional to the mass. The direction of the acceleration is the same as the direction of the net force.

$$\vec{\mathbf{a}} = \frac{\sum \vec{\mathbf{F}}}{m} \qquad \sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

SI Unit for Force

$$(\mathrm{kg})\left(\frac{\mathrm{m}}{\mathrm{s}^2}\right) = \frac{\mathrm{kg}\cdot\mathrm{m}}{\mathrm{s}^2}$$

This combination of units is called a *newton* (N).

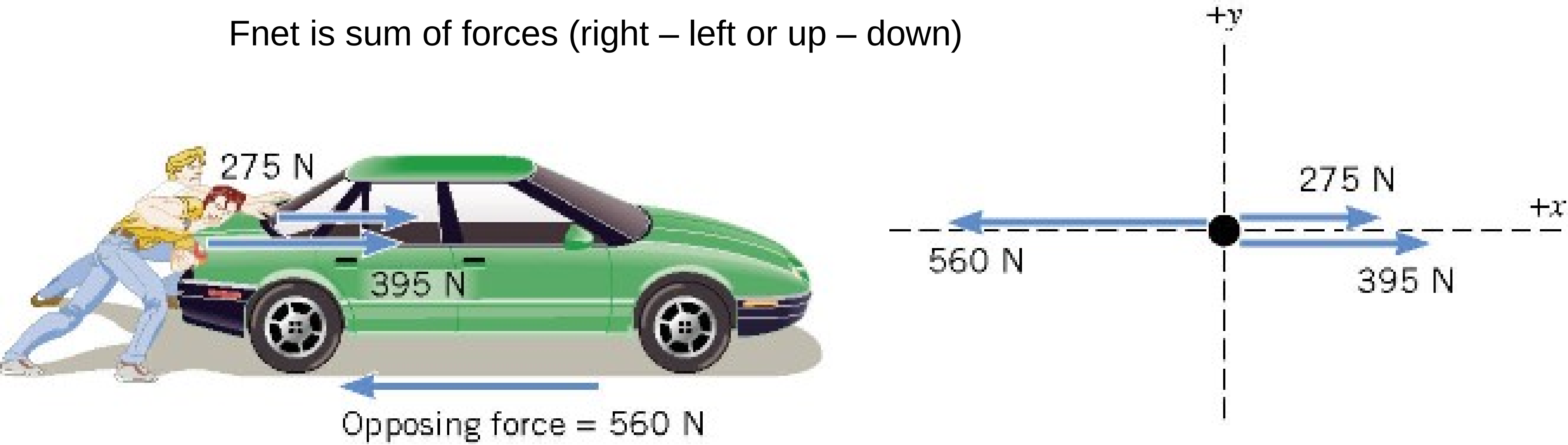
Table 4.1 Units for Mass, Acceleration, and Force

System	Mass	Acceleration	Force
SI	kilogram (kg)	meter/second^2 (m/s^2)	newton (N)
CGS	gram (g)	centimeter/second^2 (cm/s^2)	dyne (dyn)
BE	slug (sl)	foot/second^2 (ft/s^2)	pound (lb)

A ***free-body-diagram*** is a diagram that represents the object and the forces that act on it.

Remember Fnet = mass x acceleration

Fnet is sum of forces (right – left or up – down)



(a)

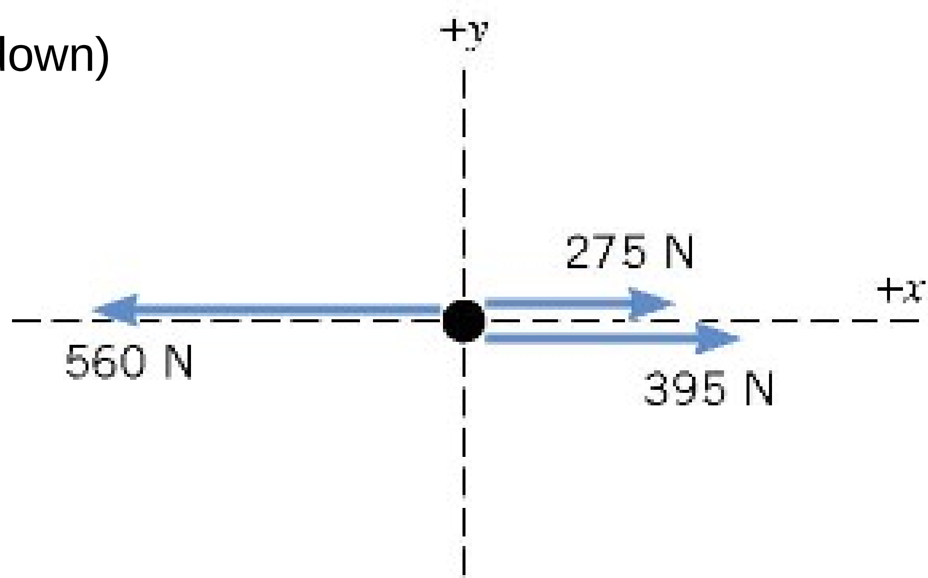
(b) Free-body diagram of the car

A ***free-body-diagram*** is a diagram that represents the object and the forces that act on it.

Remember Fnet = mass x acceleration

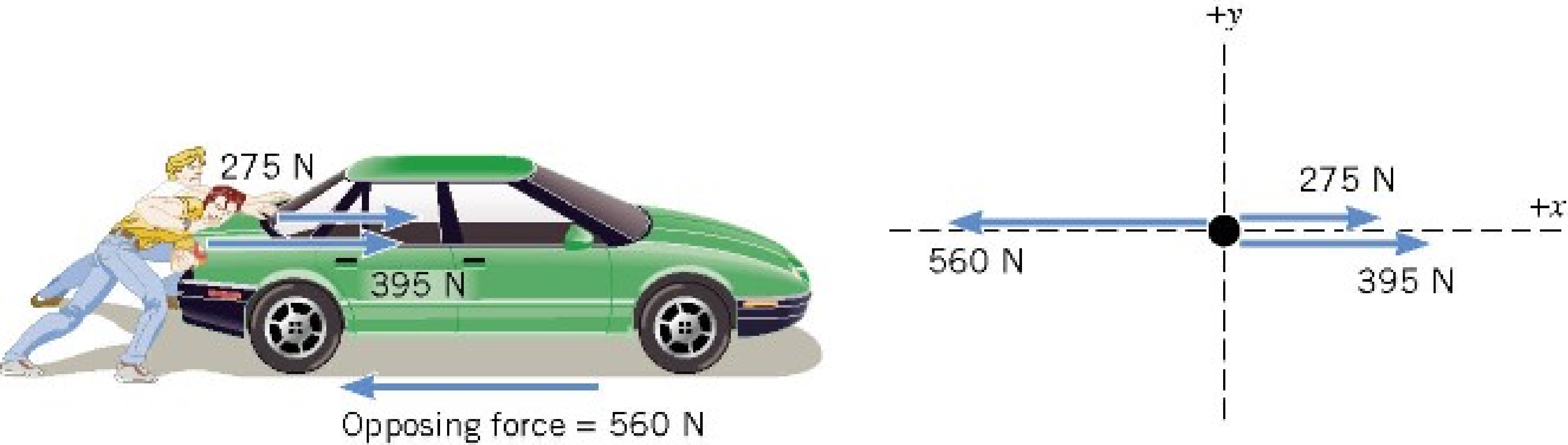
Fnet is sum of forces (right – left or up – down)

(*a*)



(*b*) Free-body diagram of the car

Newton's Second Law of Motion



(a)

(b) Free-body diagram of the car

The net force in this case is:

and is directed along the + x axis of the coordinate system.

The direction of force and acceleration vectors can be taken into account by using *x* and *y* components.

$$\sum \vec{F} = m\vec{a} \qquad \vec{F}net = m\vec{a}$$

is equivalent to:

$$\sum F_y = ma_y \qquad \sum F_x = ma_x$$

$$Fnet_y = ma_y \qquad Fnet_x = ma_x$$

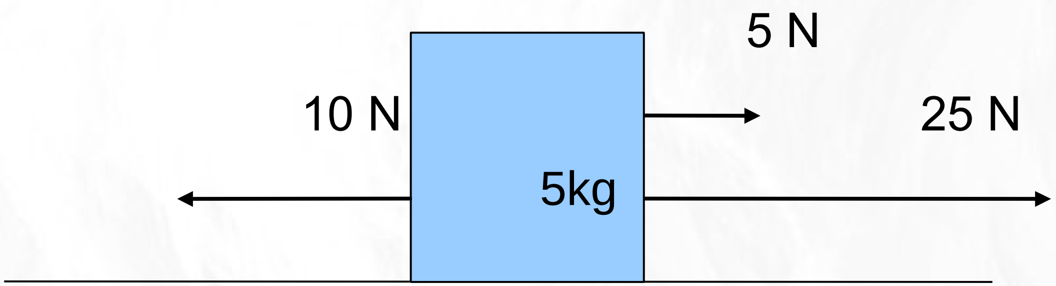
Or up - down = ma$_y$

(up is positive)

Or right - left = ma$_x$

(right is positive)

If the mass of the car is 1850 kg then, by Newton's second law, the acceleration is



Find the acceleration

Find the net force

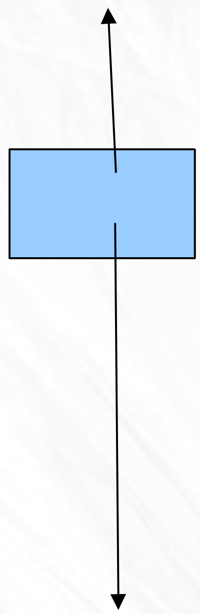
Or $right - left = ma_x$

(right is positive)

At a given instant time, a 4kg rock that has been dropped from a high cliff experiences a force of air resistance of 15N.

What are the magnitude and direction of the acceleration of the rock/

(Do not forget the gravitational force = weight of the rock)

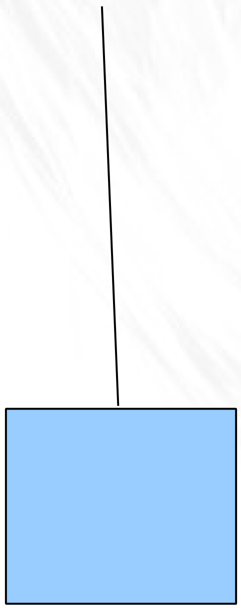


down - up = mass x acceleration

Or **up - down = ma_y**

(up is positive)

An upward force of 18N is applied via a string to lift a ball with a mass of 1.5 kg.
A)What is the net force acting upon the ball?
B)What is the acceleration of the ball ?



Draw a free body diagram

Always take the positive direction
= same direction as acceleration

Or **up - down = ma$_y$**

(up is positive)

A rope exerts a constant force of 250N to pull a 60kg crate across the floor. The velocity of the crate is observed to increase form 1m/s to 3m/s in a time of 2 seconds under the influence of this force and the frictional force exerted by the floor on the crate. Suppose it is moving @ right. Always acceleration >0

A)What is the acceleration of the crate
(kinematics. What is the definition of acceleration? Change of speed over time)

B)What is the total force acting upon the crate ?
(use Newton's second's law Fnet = mass xacceleration)

C) What is the magnitude of the frictional force acting on the crate?
(right – left = mass x acceleration)

D)What force would have to be applied to the crate by the rope for the crate to move with a constant velocity / explain./

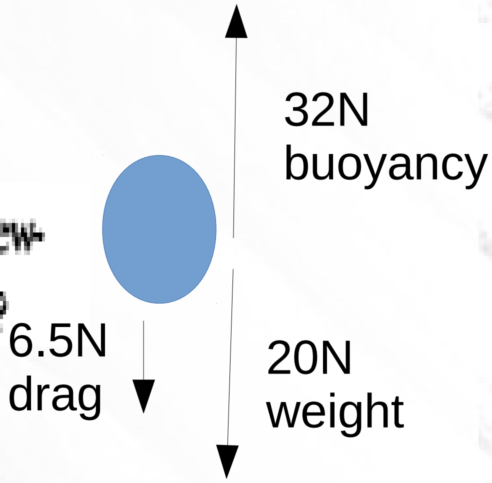
Remember Fnet = mass x acceleration

Fnet is sum of forces (right – left or up – down)

Take up to be positive and right to be positive

1 What thrust is needed to fire a 350-kilogram rocket straight up with an acceleration of 8.0 meters per second squared?

2 A 2.0-kilogram weather balloon is released and begins to rise against 6.5 newtons of viscous drag. If its buoyancy is 32 newtons, what is its acceleration?

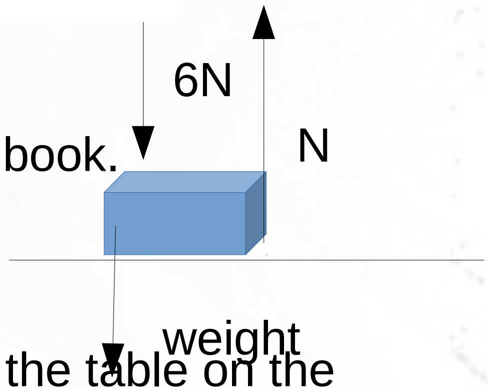


Up – down = mass x acceleration

3 What is the acceleration of a 1 200-kilogram boat if its motor produces 8 500 newtons of forward thrust and the viscous drag is 6 200 newtons?

right – left = mass x acceleration

4 What braking force is needed to bring a 2 200-kilogram car going 18 meters per second to rest in 6.0 seconds?



5) A 0.4kg book rests on a table. A downward force of 6 N is exerted on the top Of the book by a hand pushing down on the book.

A) What is the magnitude of the gravitational force acting upon the book ?

B) What is the magnitude of the upward (normal) force exerted by the table on the book ? If the book is in static equilibrium (no acceleration so up = down or up – down = 0)

6) An upward force of 18N is applied via a string to lift a ball with a mass of 1.5kg. What is the acceleration of the ball ? (up – down = mass x acceleration)

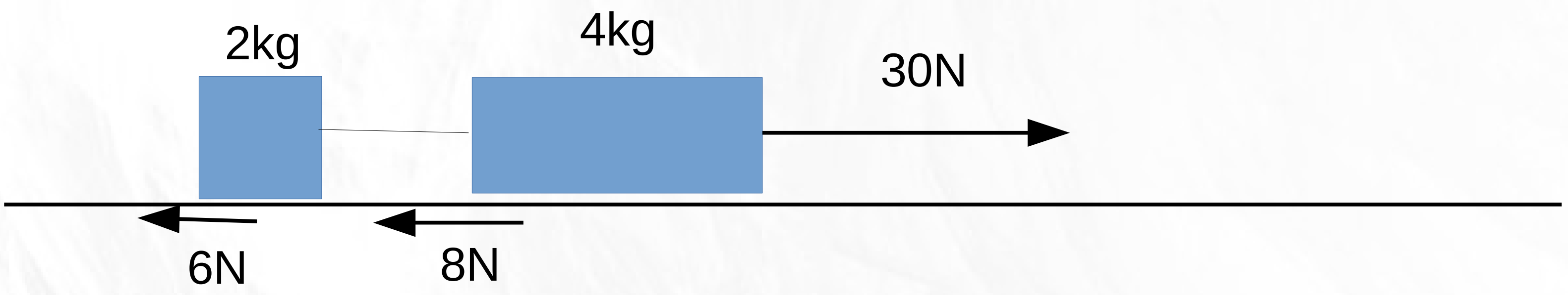
7) A constant horizontal force of 30N is exerted by a string attached to a 5 kg block being pulled Across A table. The block also experienced a frictional force of 5N due to contact with the table.

A) What is the horizontal acceleration of the block ? (right – left = mass x acceleration)

B) If the block starts from rest , what will be its velocity be after 3s ?
(use kinematics equations)

C)How far will it travel in these 3 seconds ? (kinematics equation) demo

8)



2 blocks tied together by a horizontal string are being pulled across the table
By a horizontal force of 30N as shown. The 2 kg block has a 6N frictional force exerted on it by
The table, and the 4kg block has an 8N frictional force acting on it.
A) What is the net force acting on the entire two-block system ?
(take the whole 6kg system and compute right – left = Fnet)
B) What is the acceleration of the system ? (Fnet = ma or right – left = ma)

C) What force is exerted on the 2kg block by the connecting string ? (Cut out this 2kg block
And consider only the forces Acting on this block. Its acceleration is the same as that
of the entire system).

D) Find the net force acting on the 4 kg and calculate its acceleration. How does this value
Compare to that found in B) ?

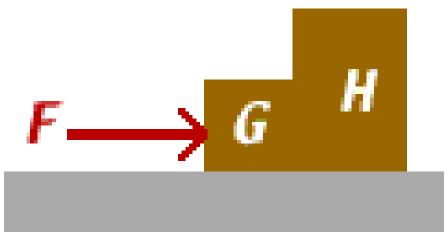
9) A dish with a mass 0.4kg has a force of kinetic friction of 0.15N exerted on it by moving a moving
Tablecloth for a time of 0.2s.
A) What is the acceleration of the dish ? (F = m a)
B) What velocity does it reach in this time , starting from rest ?
C) How far (in cm) does the dish move in this time?

12) Two cardboard boxes full of books are in contact with each other on a frictionless table. Box H has twice the mass of box G. G has a mass of 5 kg. You push on box G with a horizontal force F = 10N.   I will guide you so you can find the Force experienced by H.

1) Find the acceleration of the whole system

2) Now just consider the box G/ Its acceleration is the same as found In 1).
The forces acting on it are : the push and the recoil force from H F'.

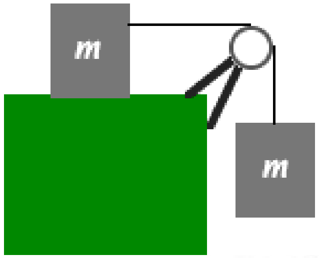
(G pushes on H so H pushes back on it). Solve for F'.
3) Now you can find the force experienced by H (same as F')

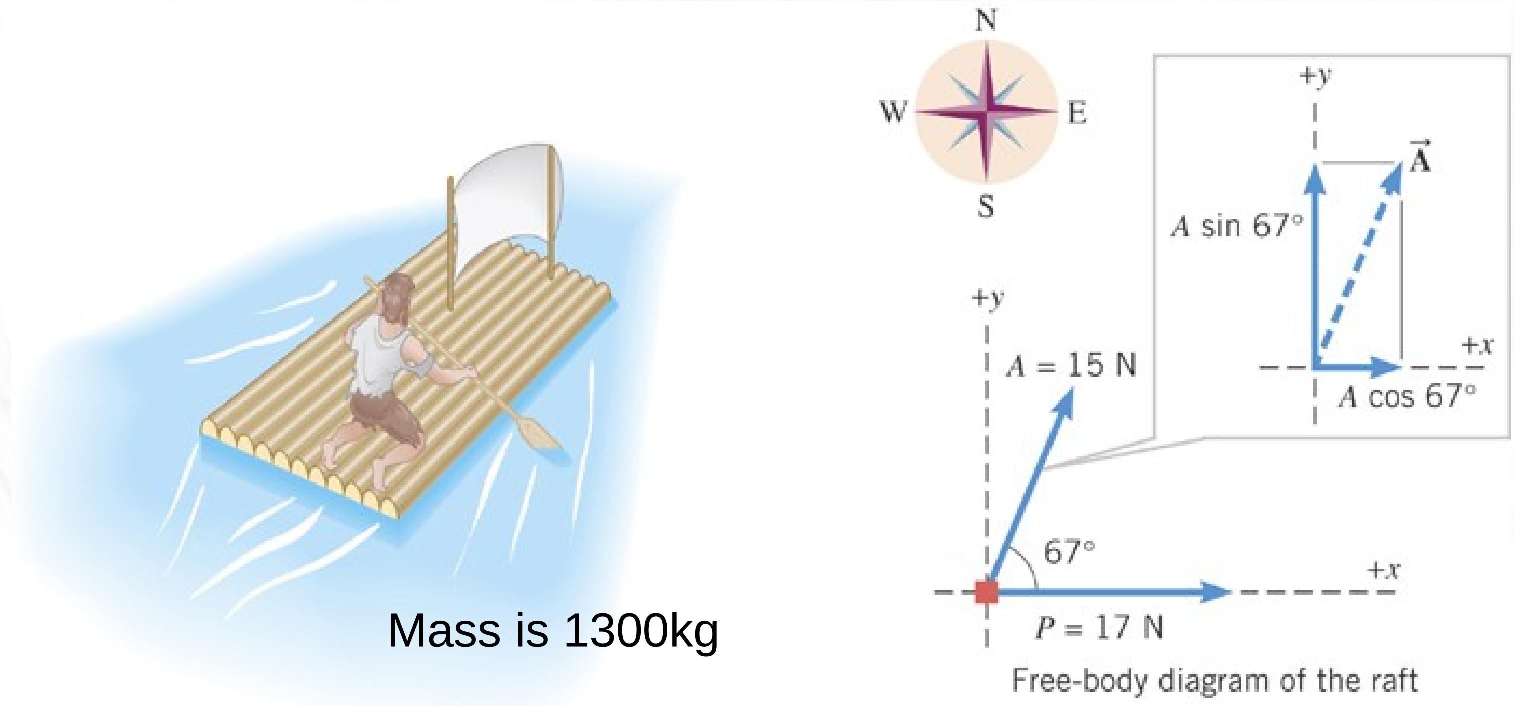


11) This system of 2 blocks is moving and speeding up. There is
No fiction involved and the goal is to find the acceleration of the system. I will guide you.
The acceleration due to gravity is g.

1) Only consider the block sliding on the table at an acceleration noted a.
The only force acting on it is T the tension of the string due to the other block.
Find the acceleration a of the block as a function of m and T.

2) Now consider the other block hanging. It has the same acceleration but it is
Experiencing 2 forces. Its weight mg and T (action reaction).
Use your result from 1) to find a as a function of g.
'
3) conclusion ? Acceleration is larger ? Smaller ? The same as g = 9.8 ?



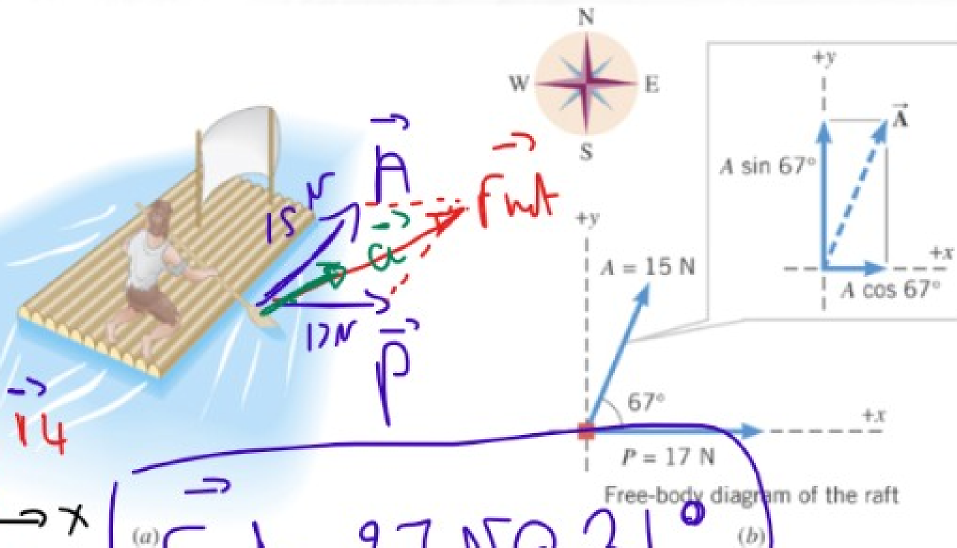


(a) (b)

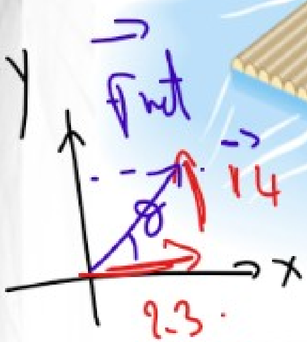
1) write the forces in standard notation
2) Use a table to find the the components of each force
3) Add the x-components to find the x-component of the net force Fx
4) Add the y-components to find the y-component of the net force Fy
5) Trace the net force F (use its components)
6) Find the magnitude and the direction of F
7) F = ___ N @ _____
8) since a = F / mass   divide the magnitude of F to find the magnitude of a
9) a = ___ m/s/s @ ______   (same direction)
10) you can find the components of a . Those are the acceleration along x or y

$\vec{A} = 15N @ 67^\circ$

$\vec{P} = 17N @ 0^\circ$



Free-body diagram of the raft



	X	Y
A	6N	14N
P	17	0
$\vec{F}_{net}$	23	14
	F_x	F_y

$\vec{F}_{net} = 27 N @ 31^\circ$

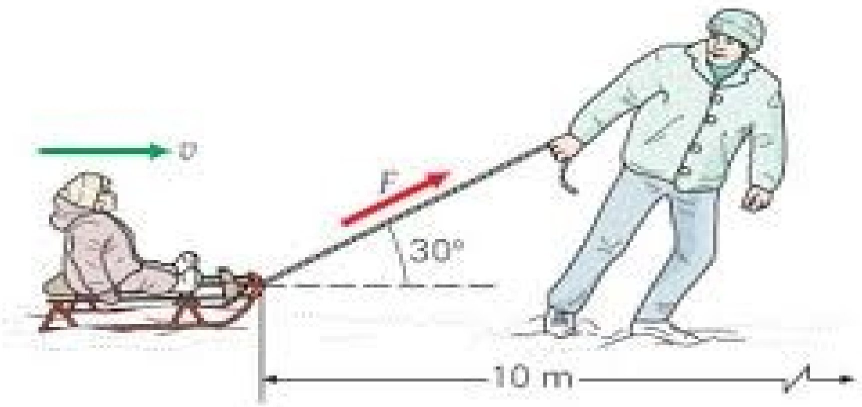
$\tan\theta = \frac{14}{23}$

$\vec{a} = \frac{\vec{F}_{net}}{mass}$

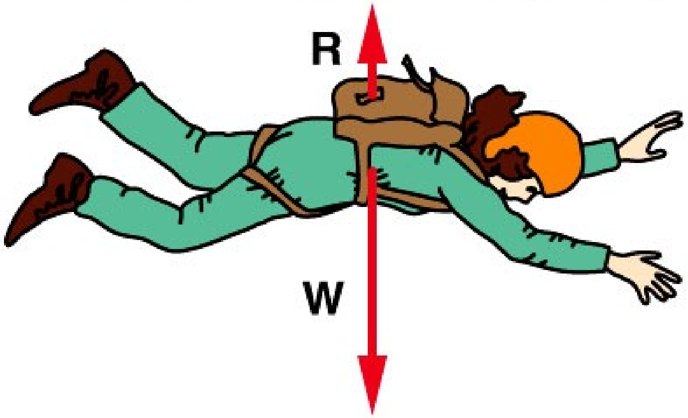
Find the acceleration along x
The acceleration along y
The total acceleration along its direction of motion
:
Mass is 1300kg

$\vec{a} = \frac{\vec{F}_{net}}{mass} = .02 m/s/s @ 31^\circ$

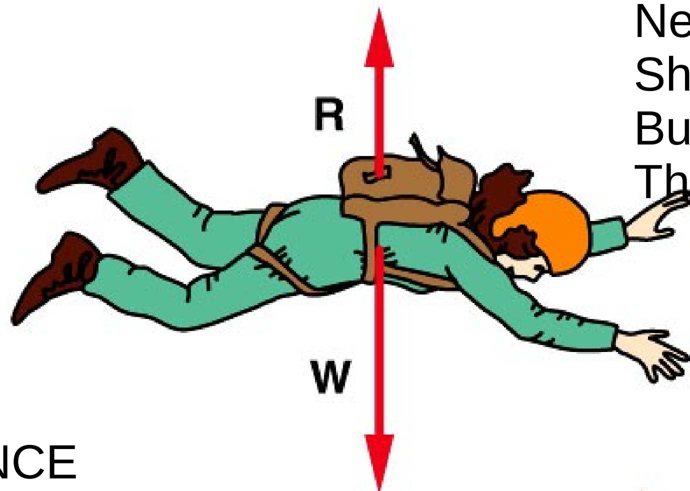
What is the acceleration of the child on the sled, with combined mass 40 kilograms, if the friction is 60 newtons and the rope is being pulled with a force of 170 newtons at an angle of 35° with the ground?



The sled is pulled over the distance 10m.
It stars from rest. What is the final speed of the sled ?



Air drag < weight -
Net force is @ down
She is accelerating @ down
The speed increases but not as much
As in free-fall
Drag increases with speed

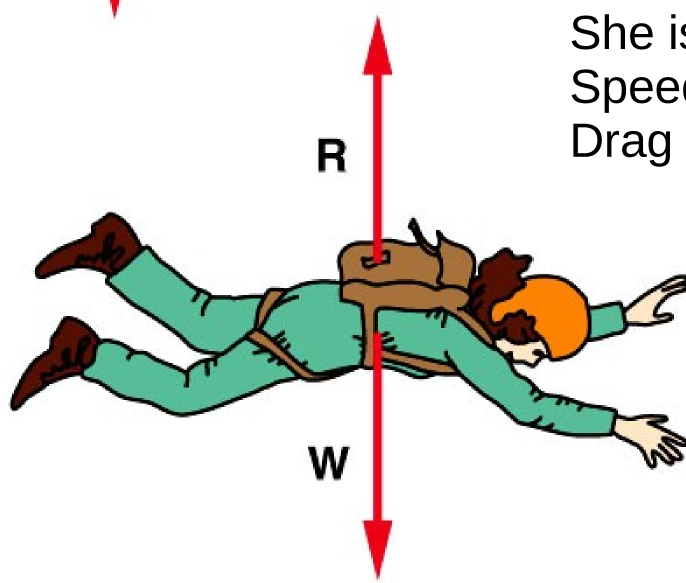


Air drag < weight
Net force smaller @ down
She is still accelerating @ down
But the acceleration is smaller.
The speed increases at a smaller rate
Drag still increases.

AIR RESISTANCE

And terminal speed

See exploration of physical



Weight = air drag
There is no acceleration
She is moving at a constant
Speed = terminal speed
Drag is constant.

She opens her parachute. Drag> weight
Now the net force is @ up so the acceleration is @ up
While she is moving @ down.
So she is slowing down and is still moving @ down.
The acceleration is negative.
Drag is increasing

Drag= weight
Net force is 0
Acceleration is 0
She is going down at a constant speed.
(terminal speed)
She is about to touch ground.

TERMINAL SPEEDS :
(from 2007 edition book from same author, Richard A. Muller)

Food dropped from airplane (3000m)
Example: Afghanistan 2002.
9mph

A person: **74mph**
(see 1000 ways to die, you can survive)

With parachute = **13mph**

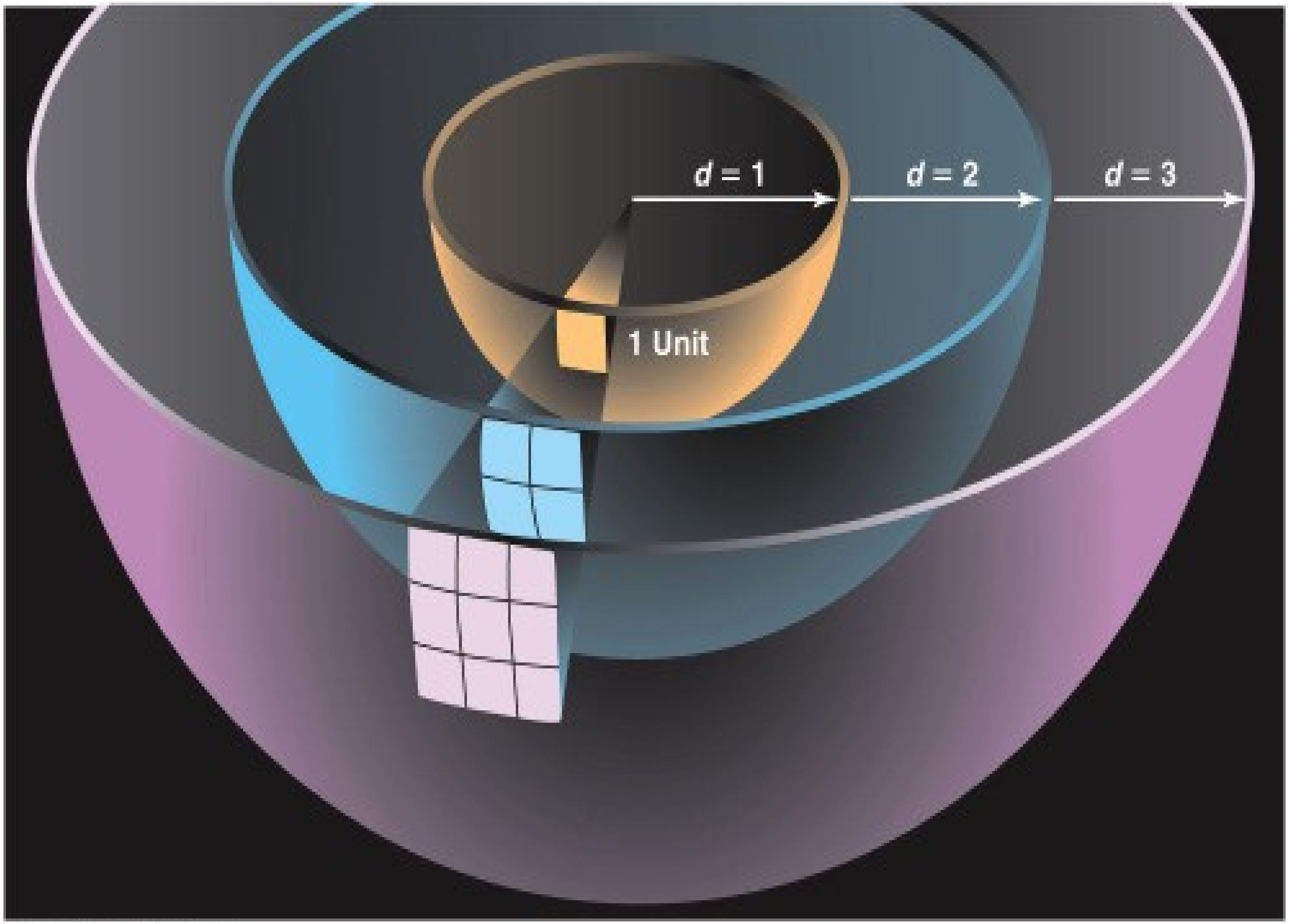
otherwise about 540 mph without air resistance
You can use the equation $\mathbf{v^2 = 2\ d\ g}$ to compute
This free-fall speed

HW to prep the test.

10) A sky diver has a weight of 750N. Suppose the air resistance force acting on the diver increases in Direct proportion to his velocity such that for every 10m/s that the driver's velocity increases, the force Of air resistance increases by 100N.
A) What is the net force acting on the sky diver when his velocity is 40m/s
B) What is the acceleration of the diver at this velocity ?
C) What is the terminal velocity of the sky diver (no acceleration, constant speeD)
D) What would happen to the velocity of the sky diver of for some reasons (a draft) his velocity Exceeded the terminal speed ? Explain ?

Gravity and weightlessness

Gravity is an inverse square law – lab inverse square law

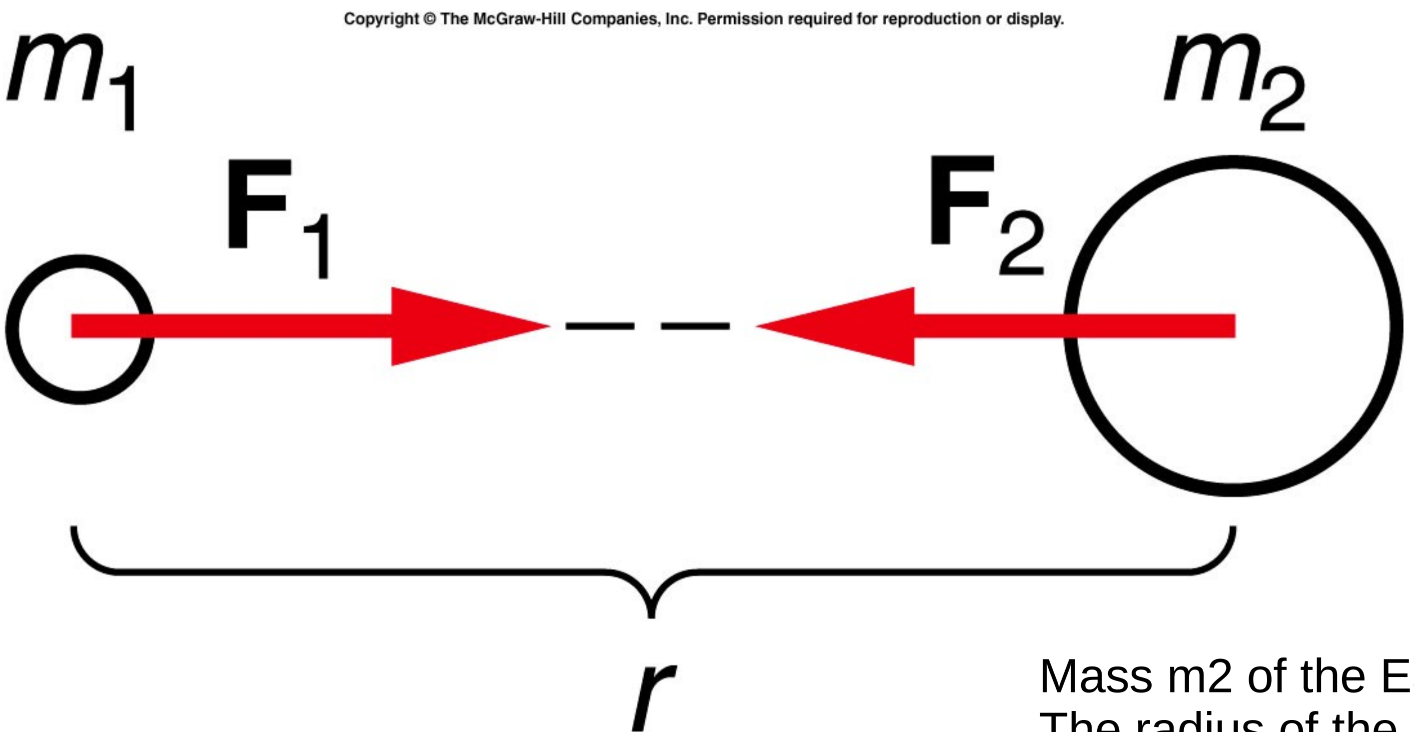


If you were to compress the Earth to the size of the Moon. The factor is 4.
What will happen to your weight?

See exploration of physical sciences. gravity

AFTER GALILEO : NEWTON

Newton unified weight, motion on earth and motion in the heaven With his universal law of gravitation.

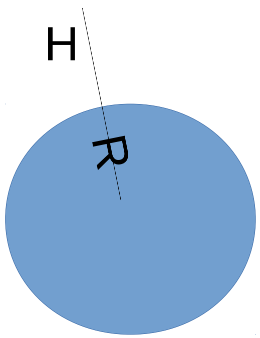


Mass m2 of the Earth is 5.972 × 10^24 kg
The radius of the Earth is 6,371 km
If you mass m1 is 60kg:
A) find the pull due to gravity
B) compare to your weight.

$G=6.67\ 10^{-11}\ Nm^2/kg^2$

$$F = G\,\frac{m_1 m_2}{r^2}$$

Supposed the earth is a sphere of radius R= 6,400 km about



At the surface g = 9.8 m/s/s
You weight is mg = G m M/ R^2
So g = G M/ R^2

Likewise at the altitude H g'=G M/ $(R+H)^2$
So g'/g =R(R+H))^2
Or **g'/9.8 =R(R+H)^2**

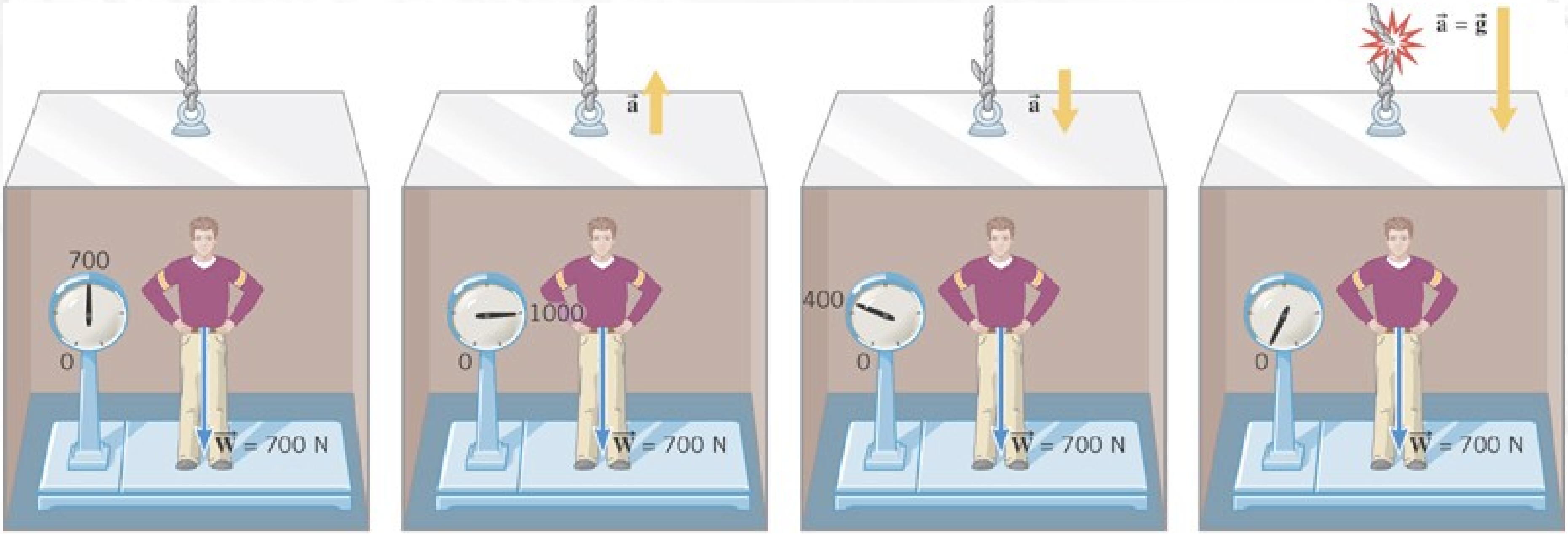
1) Find the acceleration due to gravity g' for H = 12,000km

2) find the acceleration of a piece of junk at an altitude of 22,000km.

Apparent Weight

The apparent weight of an object is the reading of the scale.

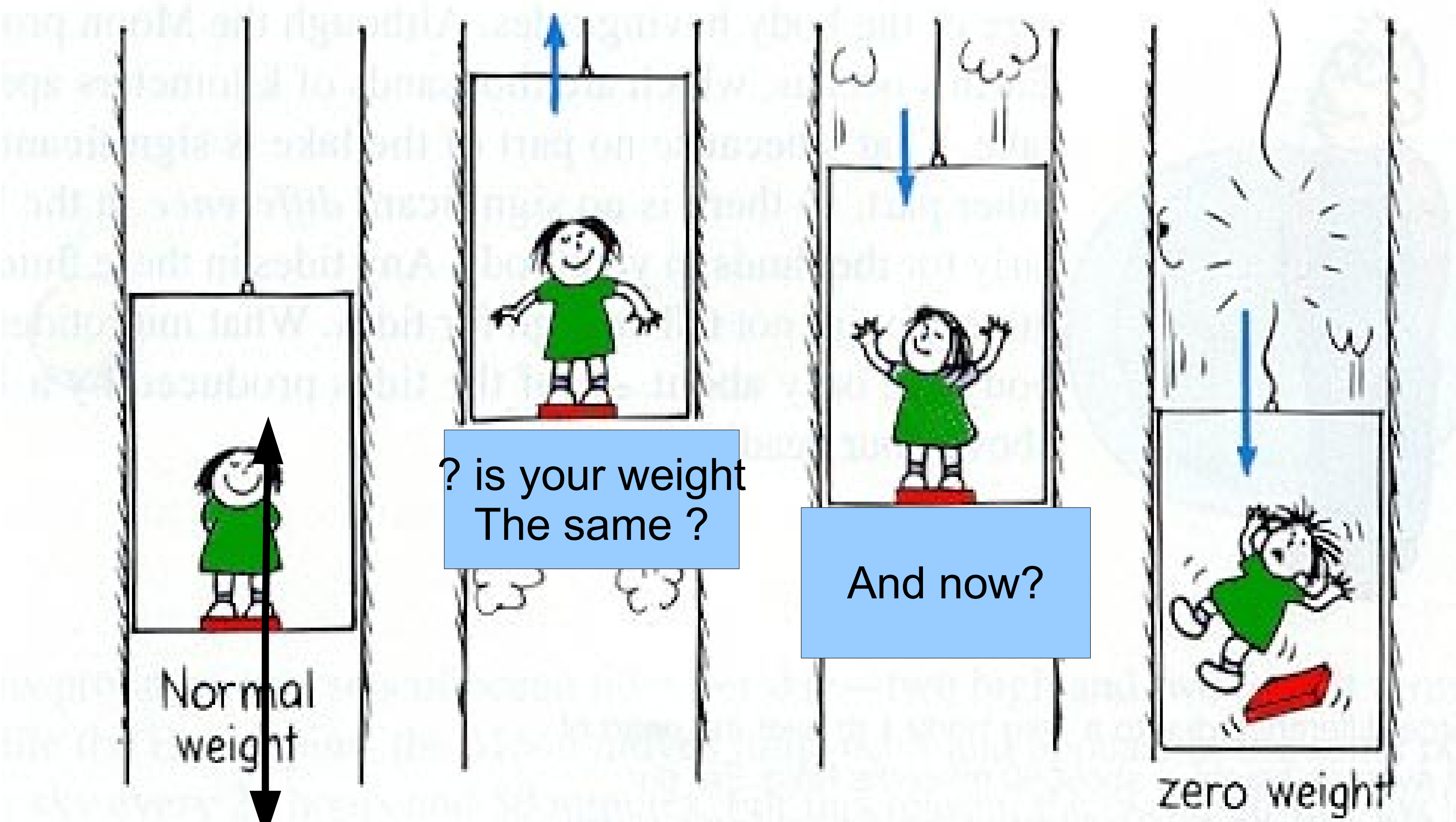
It is equal to the normal force the man exerts on the scale.



(*a*) No acceleration ($\vec{v}$ = constant) (*b*) Upward acceleration (*c*) Downward acceleration (*d*) Free-fall http://onlinephys.com/IF_04_03_ApparentWeight.htm

What is weightlessness ?

Gravity is till acting on you but you don't feel gravity anymore because There is no normal force. This is because your framework is falling With you. You are in free-fall.



The weight pulls the girl and The ground pushes the girl up This is the normal force. You feel The normal force not the weight..

The weight pulls the girl but There is no normal force. So the girls does not "feel" her weight

A 60kg woman in an elevator is accelerating upward at a rate of 1.2m/s/s
OUR system is just the woman. We are just considering the woman and the Forces acting on her.

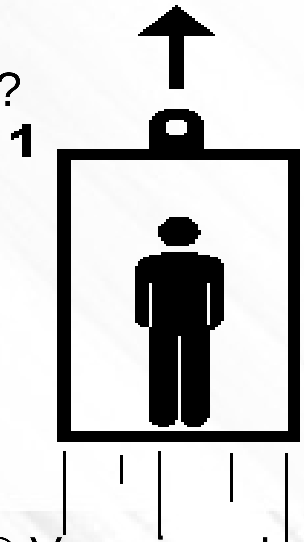
A)Just using Newton's second's law.
What is the net force acting upon the woman ? (use $Fnet_y = ma_y$)

B)Draw all the forces acting on the woman.

C)What is the gravitational force acting upon the woman / (weight = mg)

D)What is the normal force pushing upward on the woman feet
Hint: up – down = m a with up is the support force (normal force) and down is the weight,

E) If the woman were standing on a scale, the scale would read this normal force.
A scale reads what ever force you are exerting on it.
This is called her apparent weight. What is her apparent weight?



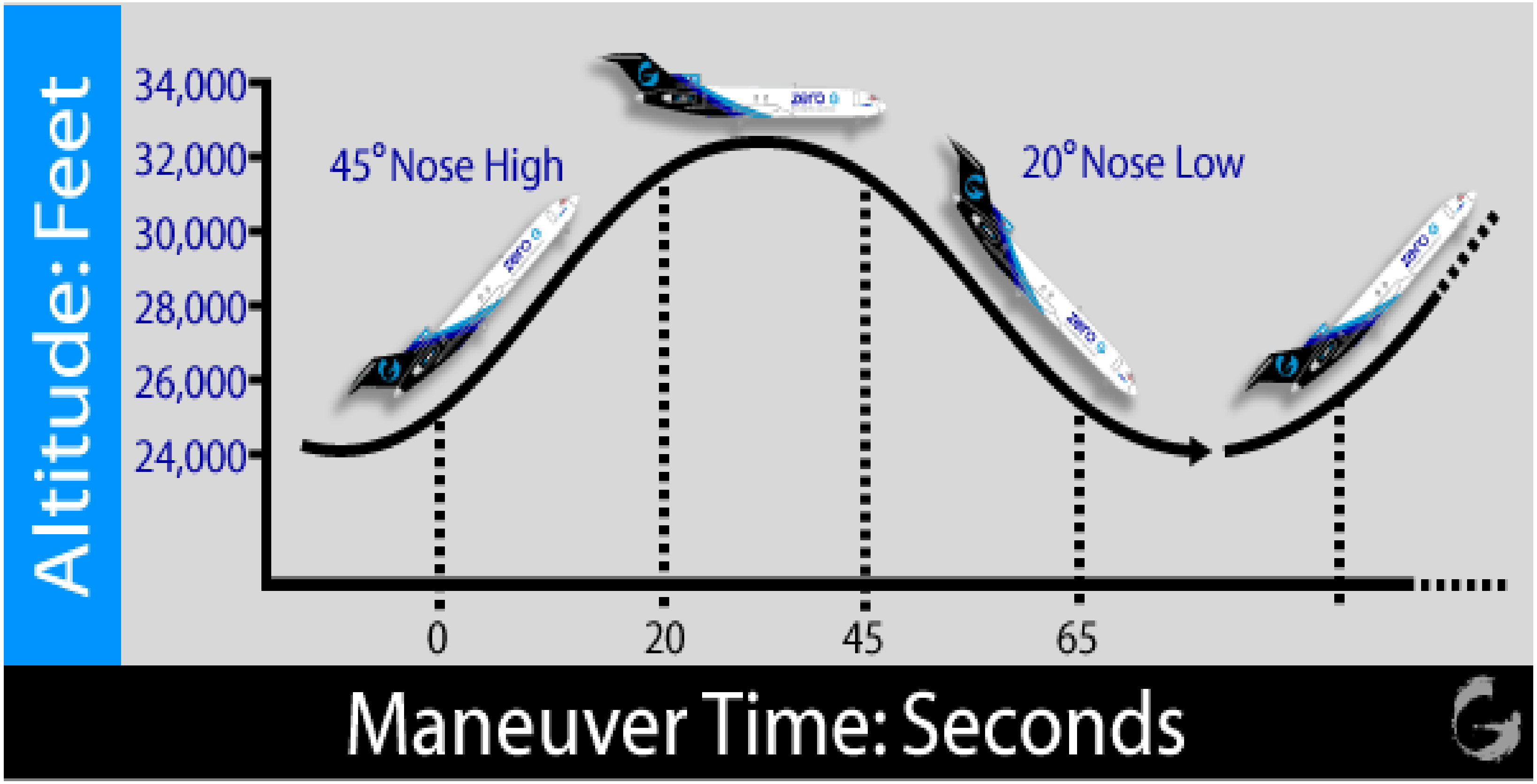
Spinning in zero gravity

http://www.youtube.com/watch?v=7tEkKhMVoS4&feature=player_embedded

http://www.youtube.com/watch?v=H0pGEq7bhLM&feature=player_embedded

Zero gravity

https://www.youtube.com/watch?v=LWGJA9i18Co



While going down the plane and its inhabitants are in zero gravity for 10-15 seconds.